LIBRARY OF THE UNIVERSITY OF CALIFORNIA

POCKET COMPANION,

CONTAINING

USEFUL INFORMATION AND TABLES,

APPERTAINING TO THE USE OF

STEEL,

AS MANUFACTURED BY

The Carnegie Steel Company, Limited,

PITTSBURG, PA.

FOR ENGINEERS, ARCHITECTS AND BUILDERS.

EDITED BY F. H. KINDL, C. E.

1893.

STEVENSON & FOSTER,
PRINTERS, ENGRAVERS AND ELECTROTYPERS,
WOOD ST., PITTSBURG, PA.

PRICE, $2.00.

PREFACE.

EDITION OF 1893.

The feature of this edition is the elimination of all data relative to iron sections. Certain changes have also been made in the dimensions of Channels, for details of which see Lithographs.

Our product hereafter will be exclusively steel.

In all respects the present edition will be found to compare favorably with its predecessors.

GENERAL NOTES.

The flanges of both I-beams and Channels have now a slope of 15 per cent.

The manner in which the weight of various sections is increased is illustrated on page 58, Figures 1, 2, 3, 4 and 5.

For Channels and I-beams the enlargement of the section adds an equal amount to the thickness of web and the width of the flanges.

The effect on angles of spreading the rolls is to slightly increase the length of the legs. Most of the sizes, however, are rolled in finishing grooves, whereby the exact dimensions are maintained for different thicknesses. These are indicated in the lithograph plates of angles. Z-bars are increased in thickness in the same manner as angles.

I-beams, Channels, Deck Beams, Angles and Z-bars can be rolled to any weight intermediate between those given. Lithographed sections shown correspond only to the minimum weight. Channels having but one weight specified can be rolled only as shown. T-shapes do not admit of any variation, and can be rolled only to the weights given. All weights given are per lineal foot of the section.

A recapitulation of all rolled shapes, with their minimum and maximum weights per foot, is given on pages 32 to 46, inclusive.

In ordering designate weight or thickness wanted, but not both.

Quicker deliveries can be made by ordering standard weights, *i. e.*, those indicated in the lithographs.

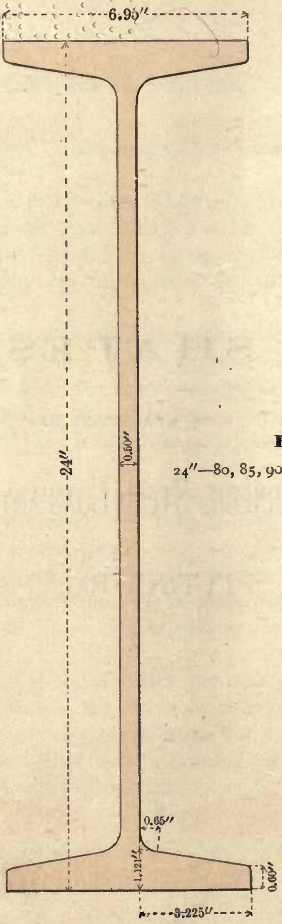
SHAPES

MANUFACTURED BY

THE CARNEGIE STEEL COMPANY, LIMITED,

PITTSBURG, PA.

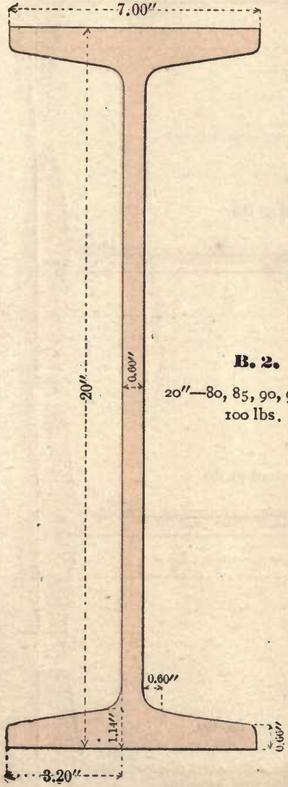
BEAMS.



B. 1.

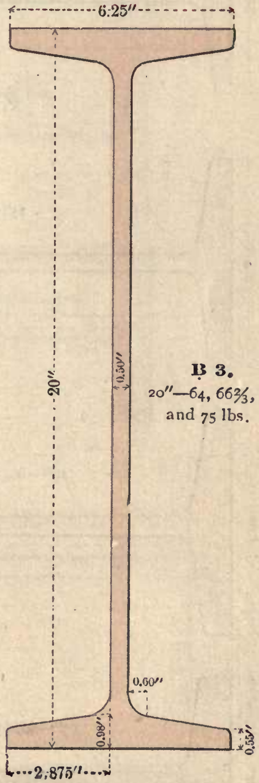
24″—80, 85, 90, 95 and 100 lbs.

BEAMS.



B. 2.

20″—80, 85, 90, 95 and 100 lbs.



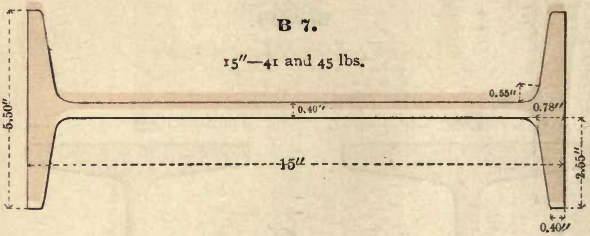
B 3.

20″—64, 66⅔, 70 and 75 lbs.

BEAMS.

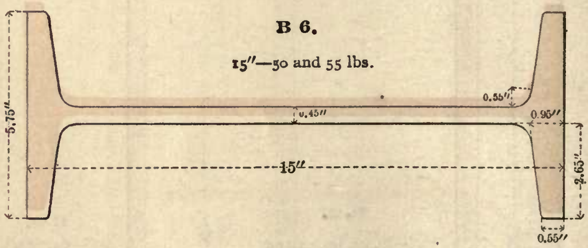
B 7.

15″—41 and 45 lbs.



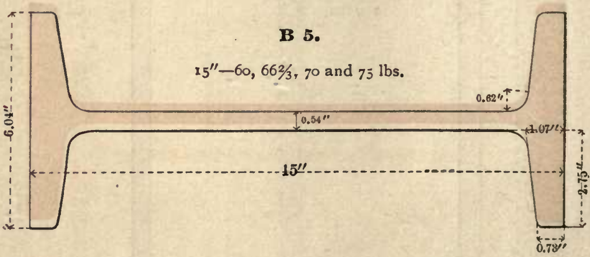
B 6.

15″—50 and 55 lbs.



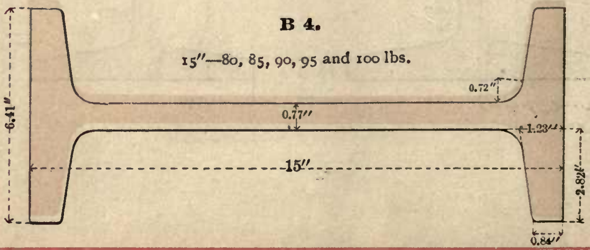
B 5.

15″—60, 66⅔, 70 and 75 lbs.



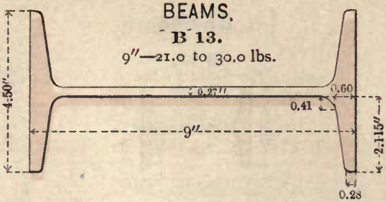
B 4.

15″—80, 85, 90, 95 and 100 lbs.

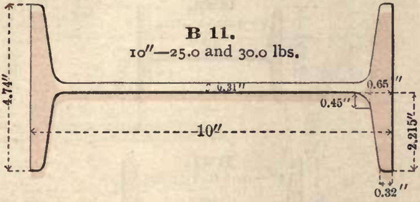


BEAMS.

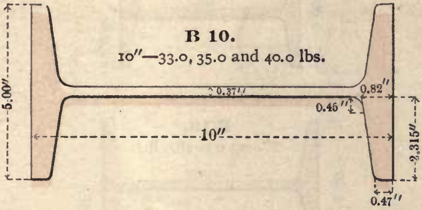
B 13.
9″—21.0 to 30.0 lbs.



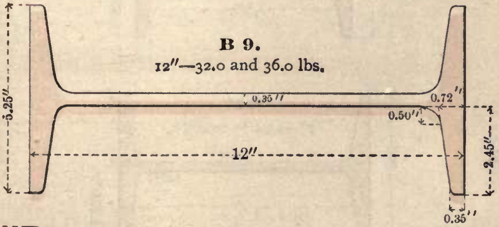
B 11.
10″—25.0 and 30.0 lbs.



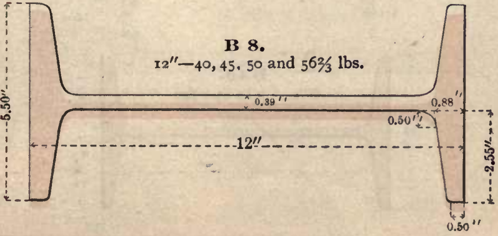
B 10.
10″—33.0, 35.0 and 40.0 lbs.



B 9.
12″—32.0 and 36.0 lbs.

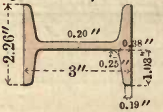


B 8.
12″—40, 45, 50 and 56⅔ lbs.

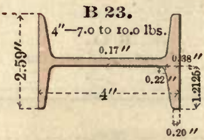


BEAMS.

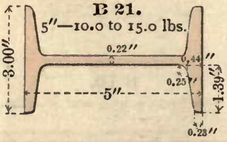
B 77.
3″—6.0 to 7.0 lbs.



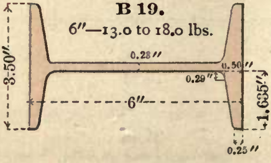
B 23.
4″—7.0 to 10.0 lbs.



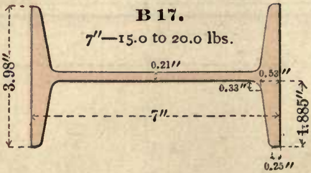
B 21.
5″—10.0 to 15.0 lbs.



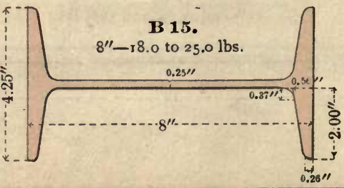
B 19.
6″—13.0 to 18.0 lbs.



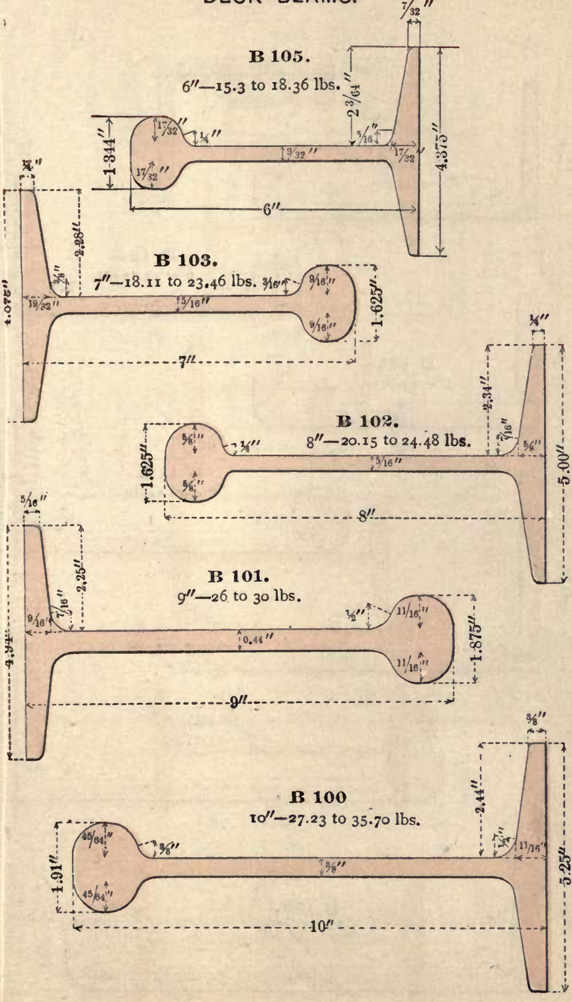
B 17.
7″—15.0 to 20.0 lbs.



B 15.
8″—18.0 to 25.0 lbs.

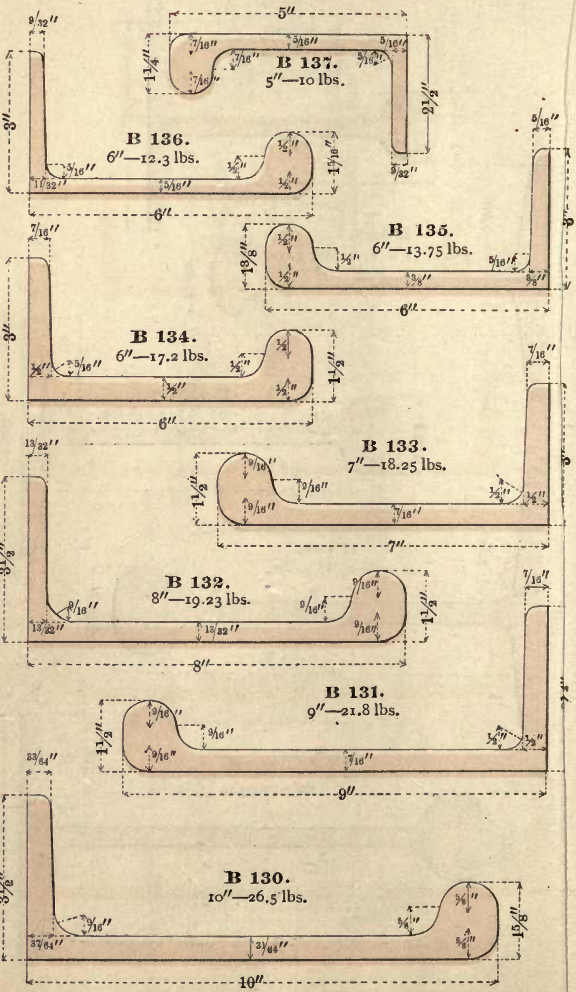


DECK BEAMS.

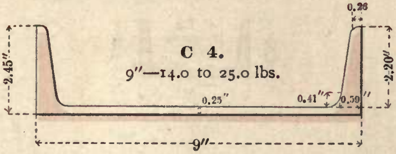


B 105.
6″—15.3 to 18.36 lbs.
B 103.
7″—18.11 to 23.46 lbs.
B 102.
8″—20.15 to 24.48 lbs.
B 101.
9″—26 to 30 lbs.
B 100
10″—27.23 to 35.70 lbs.

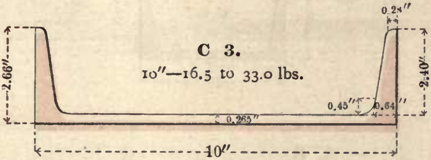
BULB ANGLES.


B 137.
5″—10 lbs.
B 136.
6″—12.3 lbs.
B 135.
6″—13.75 lbs.
B 134.
6″—17.2 lbs.
B 133.
7″—18.25 lbs.
B 132.
8″—19.23 lbs.
B 131.
9″—21.8 lbs.
B 130.
10″—26.5 lbs.

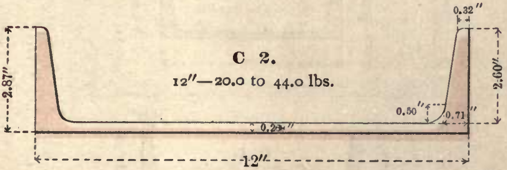
CHANNELS.



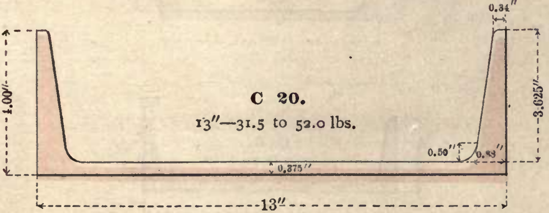
C 4.
9"—14.0 to 25.0 lbs.



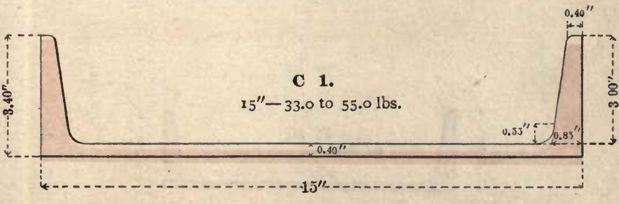
C 3.
10"—16.5 to 33.0 lbs.



C 2.
12"—20.0 to 44.0 lbs.

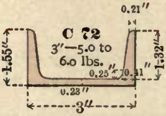


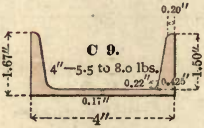
C 20.
13"—31.5 to 52.0 lbs.

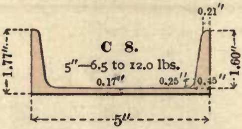


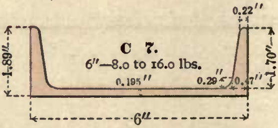
C 1.
15"—33.0 to 55.0 lbs.

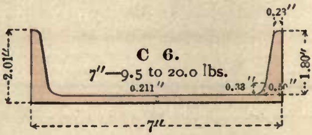
CHANNELS.

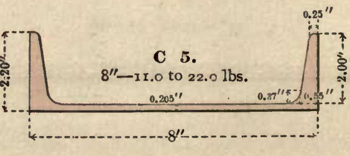

0.21″
C 72
3″—5.0 to
6.0 lbs.
0.25″
0.31″
1.55″
1.32″
0.23″
3″


0.20″
C 9.
4″—5.5 to 8.0 lbs.
0.22″
0.25″
1.67″
1.50″
0.17″
4″

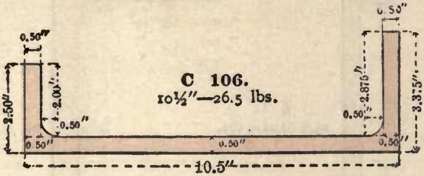

0.21″
C 8.
5″—6.5 to 12.0 lbs.
0.17″
0.25″
0.45″
1.77″
1.60″
5″


0.22″
C 7.
6″—8.0 to 16.0 lbs.
0.195″
0.29″
0.47″
1.89″
1.70″
6″

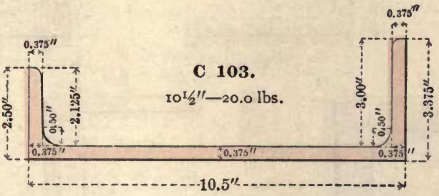

0.23″
C 6.
7″—9.5 to 20.0 lbs.
0.211″
0.33″
2.01″
1.80″
7″


0.25″
C 5.
8″—11.0 to 22.0 lbs.
0.205″
0.37″
0.55″
2.20″
2.00″
8″

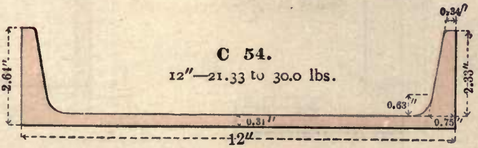
CAR TRUCK CHANNELS.
EQUAL AND UNEQUAL FLANGES.



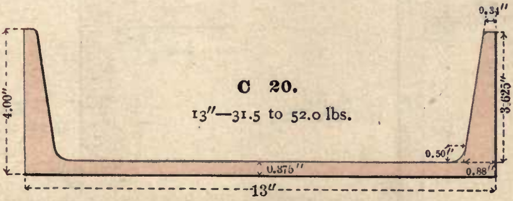
C 106.
10½"—26.5 lbs.



C 103.
10½"—20.0 lbs.

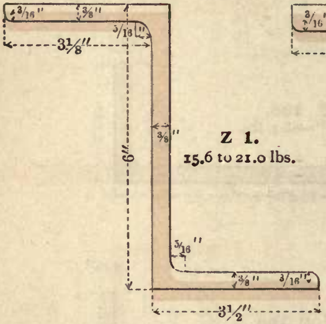


C 54.
12"—21.33 to 30.0 lbs.

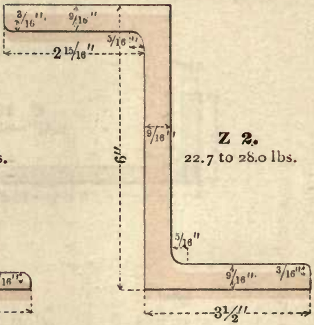


C 20.
13"—31.5 to 52.0 lbs.

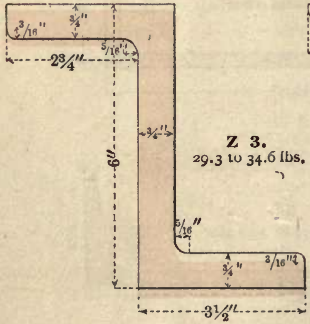
Z BARS.



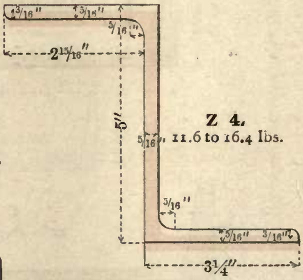
Z 1.
15.6 to 21.0 lbs.



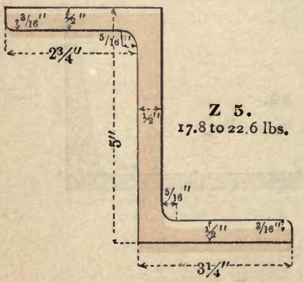
Z 2.
22.7 to 28.0 lbs.



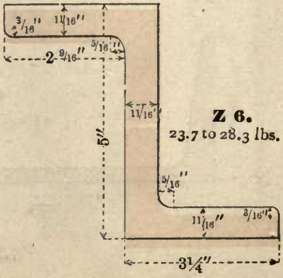
Z 3.
29.3 to 34.6 lbs.



Z 4.
11.6 to 16.4 lbs.

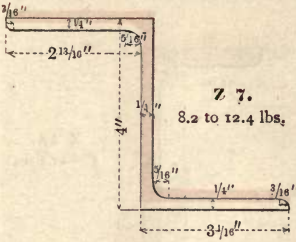


Z 5.
17.8 to 22.6 lbs.

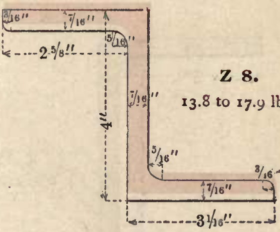


Z 6.
23.7 to 28.3 lbs.

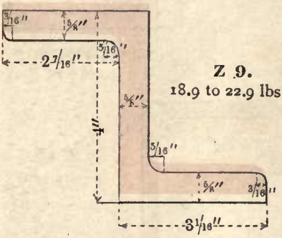
Z BARS.



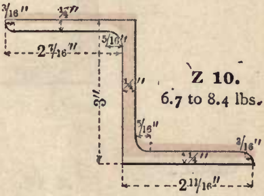
Z 7.
8.2 to 12.4 lbs.



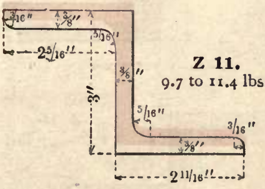
Z 8.
13.8 to 17.9 lbs.



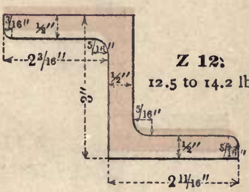
Z 9.
18.9 to 22.9 lbs.



Z 10.
6.7 to 8.4 lbs.

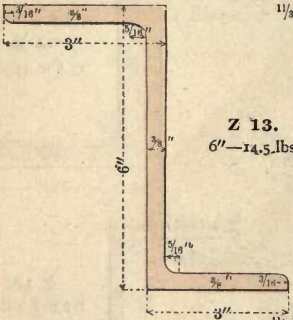


Z 11.
9.7 to 11.4 lbs.

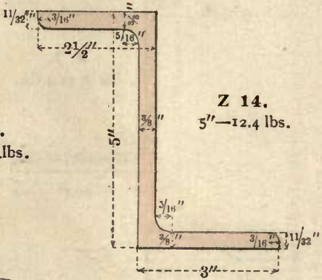


Z 12.
12.5 to 14.2 lbs.

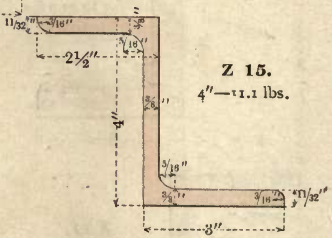
SPECIAL Z BARS.



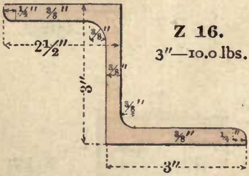
Z 13.
6"—14.5 lbs.



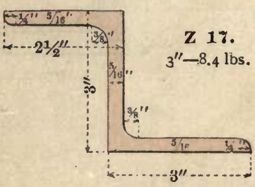
Z 14.
5"—12.4 lbs.



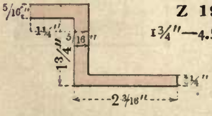
Z 15.
4"—11.1 lbs.



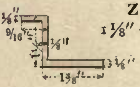
Z 16.
3"—10.0 lbs.



Z 17.
3"—8.4 lbs.



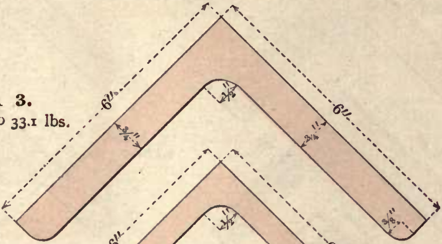
Z 19.
1¾"—4.5 lbs.



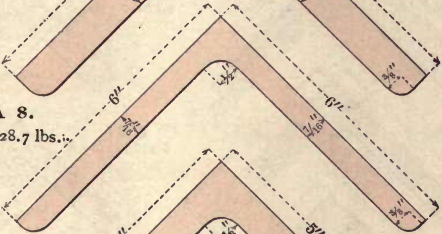
Z 18.
1⅛"—1.3 lbs.

ANGLES WITH EQUAL LEGS.

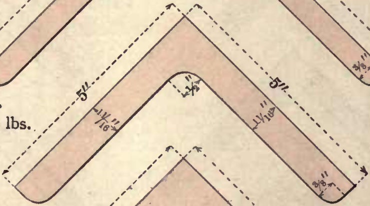
A 3.
28.7 to 33.1 lbs.



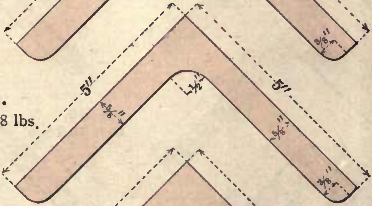
A 8.
17.2 to 28.7 lbs.



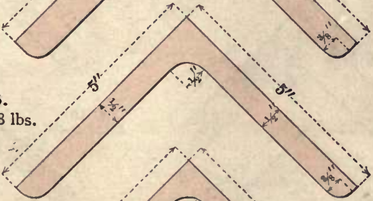
A 12.
21.8 to 27.2 lbs.



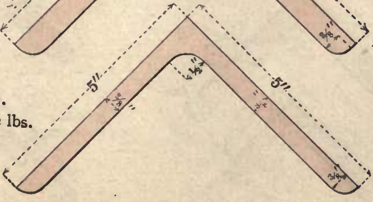
A 13.
20.0 to 21.8 lbs.



A 15.
16.2 to 21.8 lbs.



A 17.
12.3 to 16.2 lbs.



ANGLES WITH EQUAL LEGS

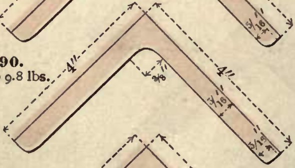
A 20.
17.1 to 19.9 lbs.

A 21.
15.7 to 17.2 lbs.

A 23.
12.8 to 17.1 lbs.

A 25.
9.8 to 12.8 lbs.

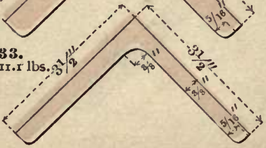
A 90.
8.2 to 9.8 lbs.



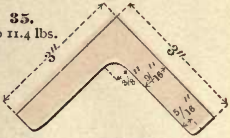
A 28.
14.8 to 17.1 lbs.

A 31.
11.1 to 14.8 lbs.

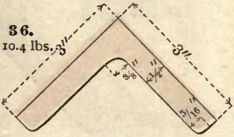
A 33.
8.5 to 11.1 lbs.



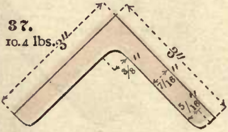
A 35.
10.4 to 11.4 lbs.



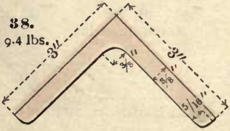
A 36.
9.4 to 10.4 lbs.



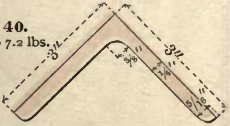
A 37.
8.3 to 10.4 lbs.



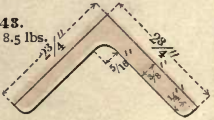
A 38.
7.2 to 9.4 lbs.



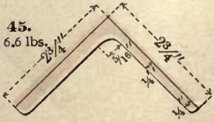
A 40.
4.9 to 7.2 lbs.



A 43.
6.6 to 8.5 lbs.

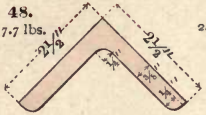


A 45.
4.5 to 6.6 lbs.

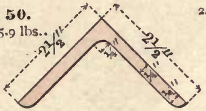


ANGLES WITH EQUAL LEGS.

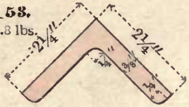
A 48.
5.9 to 7.7 lbs.



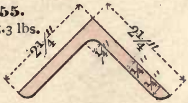
A 50.
4.1 to 5.9 lbs.



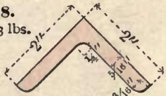
A 53.
5.3 to 6.8 lbs.



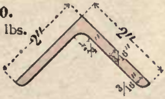
A 55.
3.7 to 5.3 lbs.



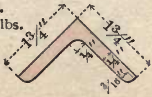
A 58.
4.0 to 5.3 lbs.



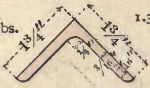
A 60.
2.5 to 4.0 lbs.



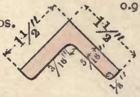
A 64.
2.8 to 4.6 lbs.



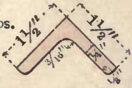
A 65.
2.1 to 2.8 lbs.



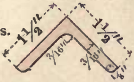
A 67.
2.9 to 3.4 lbs.



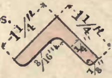
A 68.
2.4 to 2.9 lbs.



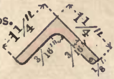
A 69.
1.8 to 2.4 lbs.



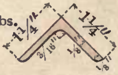
A 71.
1.9 to 2.4 lbs.



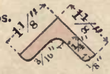
A 72.
1.5 to 1.9 lbs.



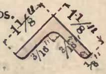
A 73.
1.0 to 1.5 lbs.



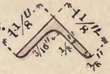
A 75.
1.7 to 2.1 lbs.



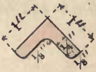
A 76.
1.3 to 1.7 lbs.



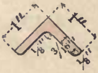
A 77.
0.9 to 1.3 lbs.



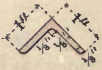
A 78.
1.5 lbs.



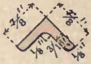
A 79.
1.2 lbs.



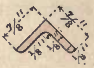
A 80.
0.8 lb.



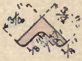
A 81.
1.0 lb.



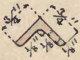
A 82.
0.7 lb.



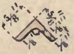
A 83.
0.8 lb.



A 84.
0.6 lb.



A 85.
0.5 lb.



ANGLES WITH UNEQUAL LEGS.

A 154.
24.9 to 32.3 lbs.

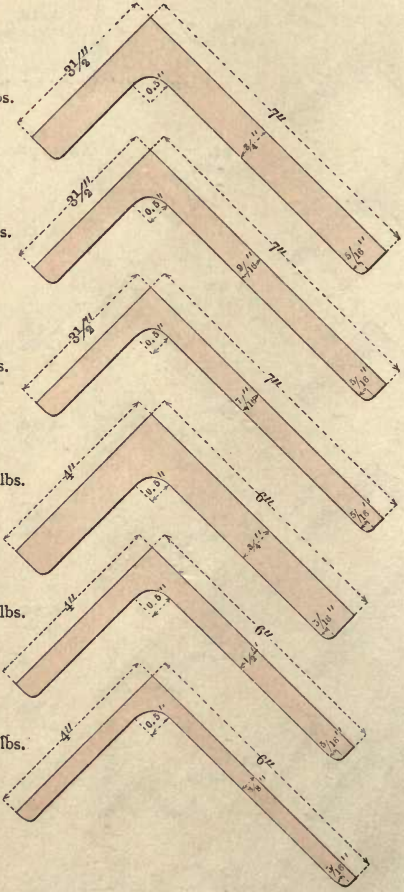
A 157.
19.0 to 24.9 lbs.

A 159.
15.0 to 19.0 lbs.

A 162.
23.6 to 27.2 lbs.

A 166.
16.2 to 23.6 lbs.

A 168.
12.3 to 16.2 lbs.



ANGLES WITH UNEQUAL LEGS.

A 171.
22.3 to 25.7 lbs.

A 175.
15.3 to 22.3 lbs.

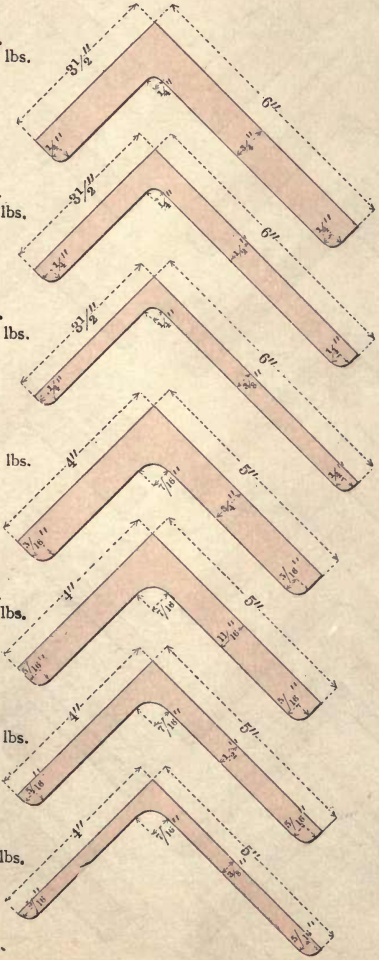
A 177.
11.7 to 15.3 lbs.

A 180
21.1 to 24.2 lbs.

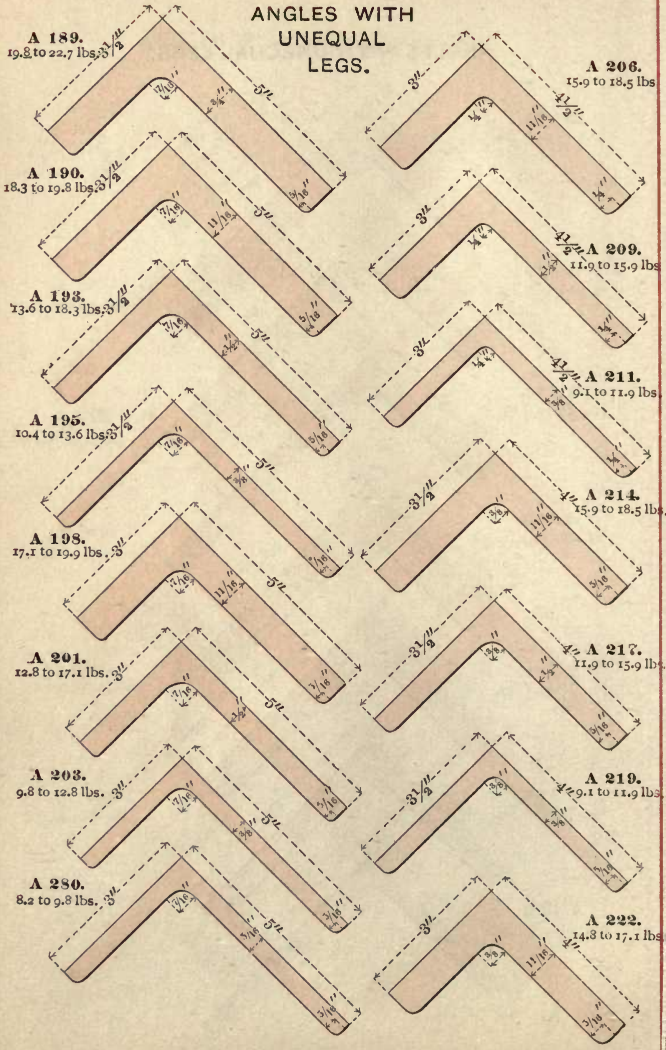
A 181.
19.5 to 24.2 lbs.

A 184.
14.5 to 19.5 lbs.

A 186.
11.0 to 14.5 lbs.

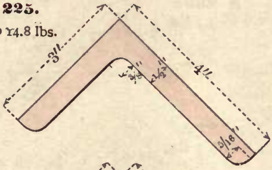


ANGLES WITH UNEQUAL LEGS.

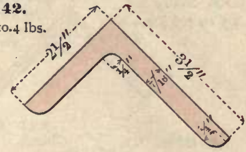


ANGLES WITH UNEQUAL LEGS.

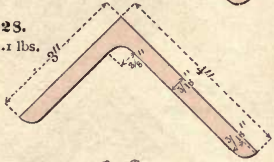
A 225.
11.1 to 14.8 lbs.



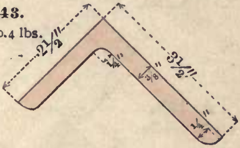
A 242.
8.3 to 10.4 lbs.



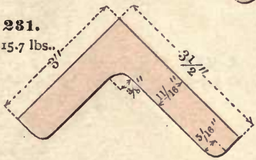
A 228.
7.1 to 11.1 lbs.



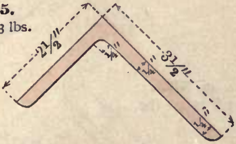
A 243.
7.2 to 10.4 lbs.



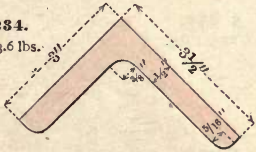
A 231.
13.6 to 15.7 lbs.



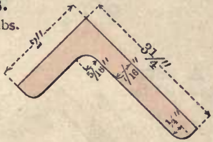
A 245.
4.9 to 8.3 lbs.



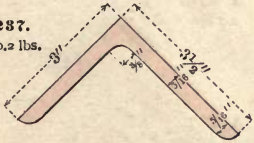
A 234.
10.2 to 13.6 lbs.



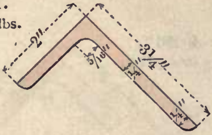
A 248.
7.2 to 9.0 lbs.



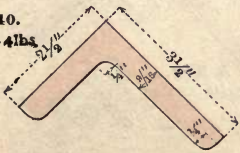
A 237.
6.6 to 10.2 lbs.



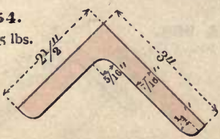
A 251.
4.3 to 7.2 lbs.



A 240.
10.4 to 12.4 lbs.

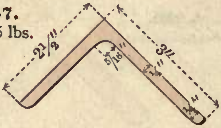


A 254.
7.6 to 9.5 lbs.



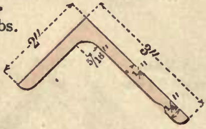
ANGLES WITH UNEQUAL LEGS.

A 257.
4.5 to 7.6 lbs.

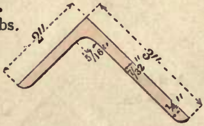


A 259.
6.8 to 7.7 lbs.

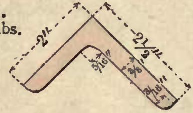
A 262.
4.1 to 6.8 lbs.



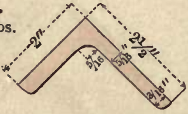
A 263.
3.6 to 4.1 lbs.



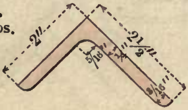
A 266.
5.3 to 6.8 lbs.



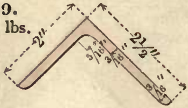
A 267.
4.5 to 5.3 lbs.



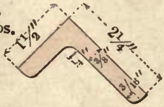
A 268.
3.7 to 4.5 lbs.



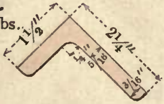
A 269.
2.8 to 3.7 lbs.



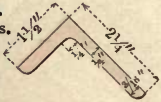
A 272.
4.3 to 5.5 lbs.



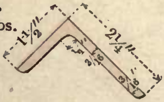
A 273.
3.7 to 4.3 lbs.



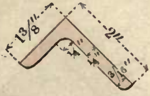
A 274.
3.0 to 3.7 lbs.



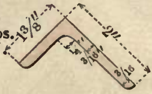
A 275.
2.3 to 3.0 lbs.



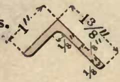
A 276.
2.7 lbs.



A 277.
2.1 to 2.7 lbs.

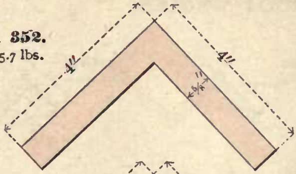


A 279.
1.0 to 1.6 lbs.

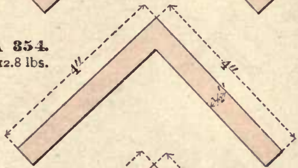


SQUARE ROOT ANGLES.

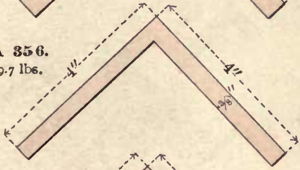
A 352.
15.7 lbs.



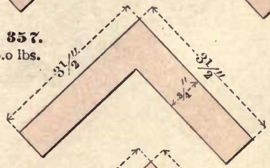
A 354.
12.8 lbs.



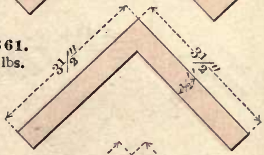
A 356.
9.7 lbs.



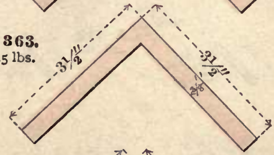
A 357.
16.0 lbs.



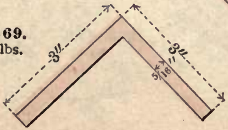
A 361.
11.0 lbs.



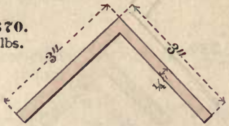
A 363.
8.5 lbs.



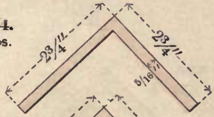
A 369.
6.0 lbs.



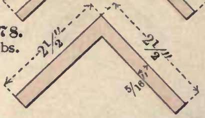
A 370.
4.9 lbs.



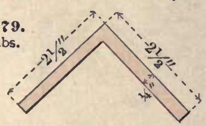
A 374.
5.5 lbs.



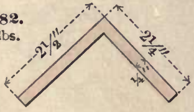
A 378.
5.0 lbs.



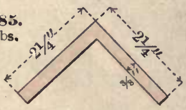
A 379.
4.1 lbs.



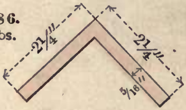
A 382.
3.9 lbs.



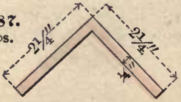
A 385.
5.3 lbs.



A 386.
4.5 lbs.



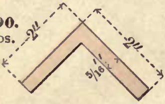
A 387.
3.6 lbs.



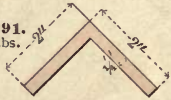
SQUARE ROOT ANGLES.

A 389.
4.7 lbs.

A 390.
3.9 lbs.

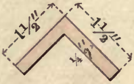


A 391.
3.2 lbs.

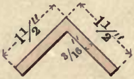


A 395
2.8 lbs.

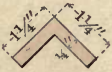
A 398.
2.4 lbs.



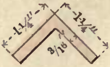
A 399.
1.9 lbs.



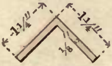
A 401.
2.0 lbs.



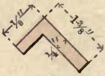
A 402.
1.5 lbs.



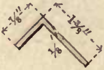
A 403.
1.0 lb.



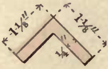
A 404.
1.8 lbs.



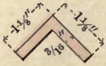
A 405.
0.9 lb.



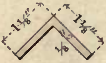
A 406.
1.7 lbs.



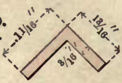
A 407.
1.3 lbs.



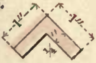
A 408.
0.9 lb.



A 430.
1.1 lbs.

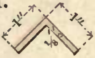


A 409.
1.5 lbs.

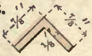


A 410.
1.1 lbs.

A 411.
0.8 lb.



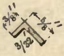
A 413.
0.7 lb.



A 414.
0.8 lb.

A 415.
0.6 lb.

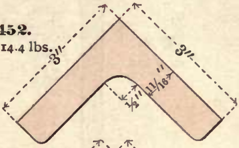
A 416.
0.3 lb.



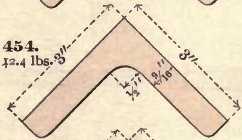
SPECIAL ANGLES.

COVER ANGLES.

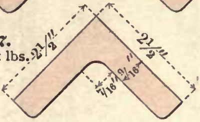
A 452.
12.4 to 14.4 lbs.



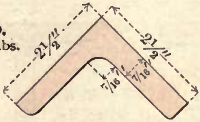
A 454.
10.4 to 12.4 lbs.



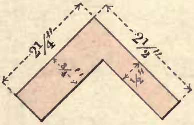
A 457.
8.5 to 10.1 lbs.



A 459.
6.8 to 8.5 lbs.

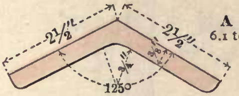


A 460.
8.7 lbs.

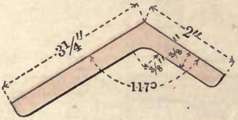


OBTUSE ANGLES.

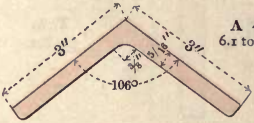
A 463.
6.1 to 8.2 lbs.



A 466.
6.1 to 8.2 lbs

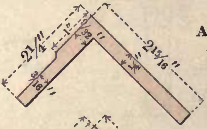


A 469.
6.1 to 8.4 lbs.

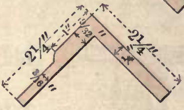


SAFE ANGLES.

A 470.
4.2 lbs.

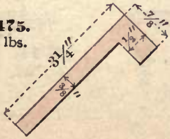


A 471.
3.5 lbs.

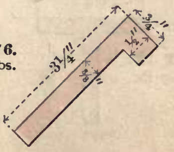


HALF TEES.

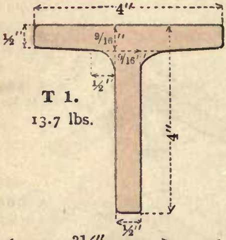
A 475.
4.9 lbs.



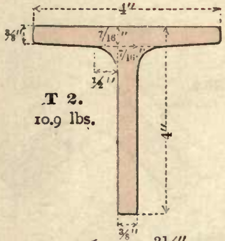
A 476.
4.6 lbs.



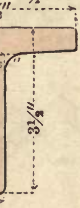
TEES WITH EQUAL LEGS.



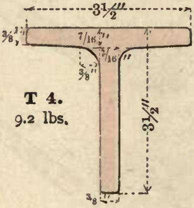
T 1.
13.7 lbs.



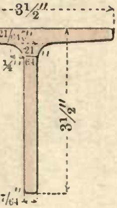
T 2.
10.9 lbs.



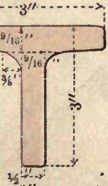
T 3.
11.7 lbs.



T 4.
9.2 lbs.

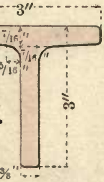


T 5.
6.8 lbs.



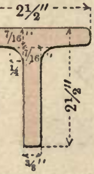
T 6.
10.0 lbs.

T 7.
9.1 lbs.

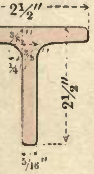


T 8.
7.8 lbs.

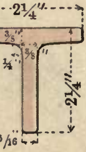
T 9.
6.6 lbs.



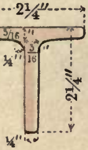
T 10.
6.4 lbs.



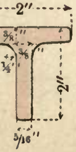
T 11.
5.5 lbs.



T 12.
4.9 lbs.



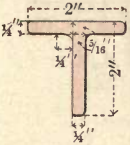
T 13.
4.1 lbs.



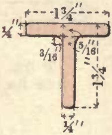
T 14.
4.3 lbs.

TEES WITH EQUAL LEGS.

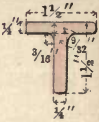
T 15.
3.7 lbs.



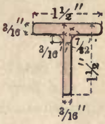
T 16.
3.1 lbs.



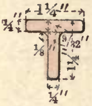
T 17.
2.6 lbs.



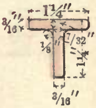
T 18.
1.84 lbs.



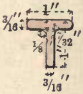
T 19.
2.04 lbs.



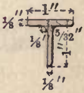
T 20.
1.53 lbs.



T 21.
1.23 lbs.



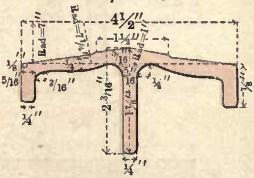
T 22.
0.87 lb.



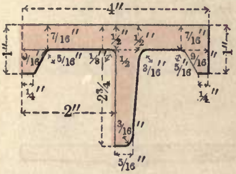
SPECIAL TEES.

HAND RAILS.

T 154.
7.0 lbs.

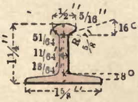


T 156.
11.0 lbs.

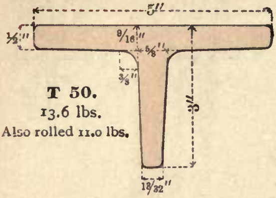


RAIL.

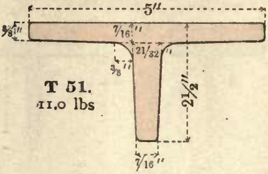
R 4.
1¾ lbs.



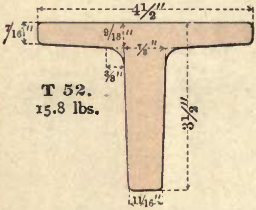
TEES WITH UNEQUAL LEGS.



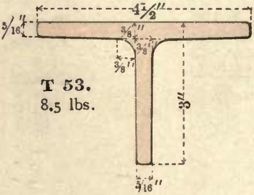
T 50.
13.6 lbs.
Also rolled 11.0 lbs.



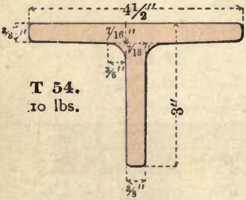
T 51.
11.0 lbs



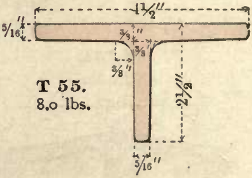
T 52.
15.8 lbs.



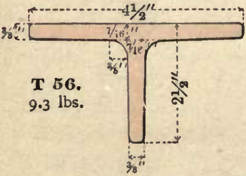
T 53.
8.5 lbs.



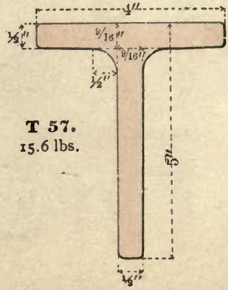
T 54.
10 lbs.



T 55.
8.0 lbs.

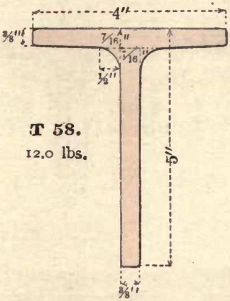


T 56.
9.3 lbs.

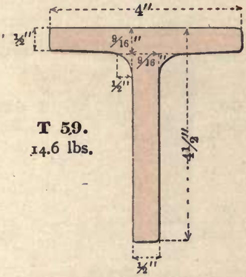


T 57.
15.6 lbs.

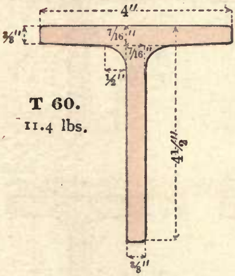
TEES WITH UNEQUAL LEGS.



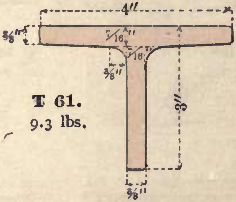
T 58.
12.0 lbs.



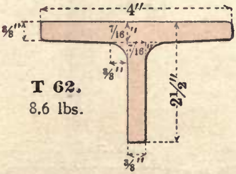
T 59.
14.6 lbs.



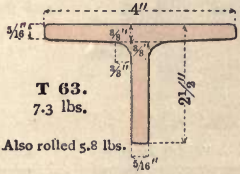
T 60.
11.4 lbs.



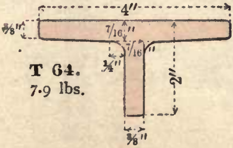
T 61.
9.3 lbs.



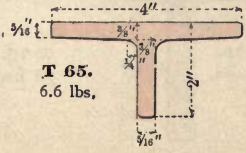
T 62.
8.6 lbs.



T 63.
7.3 lbs.
Also rolled 5.8 lbs.

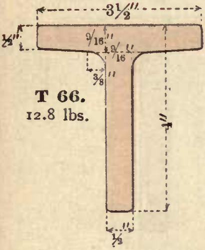


T 64.
7.9 lbs.

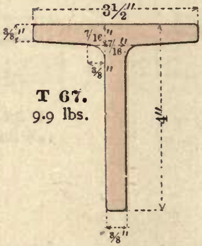


T 65.
6.6 lbs.

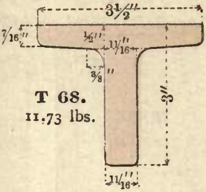
TEES WITH UNEQUAL LEGS.



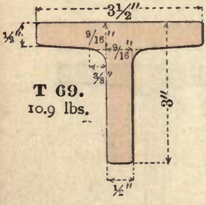
T 66.
12.8 lbs.



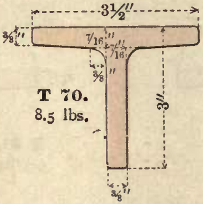
T 67.
9.9 lbs.



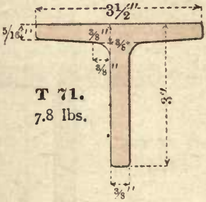
T 68.
11.73 lbs.



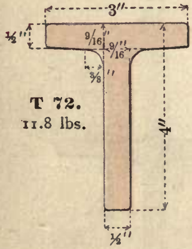
T 69.
10.9 lbs.



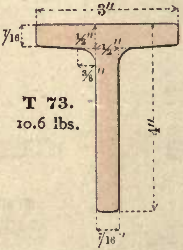
T 70.
8.5 lbs.



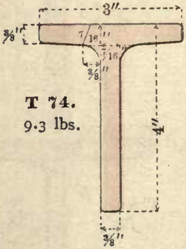
T 71.
7.8 lbs.



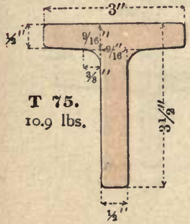
T 72.
11.8 lbs.



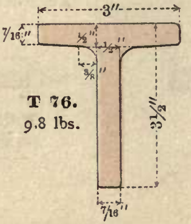
T 73.
10.6 lbs.



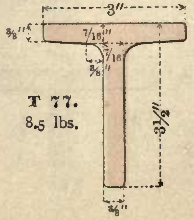
T 74.
9.3 lbs.



T 75.
10.9 lbs.

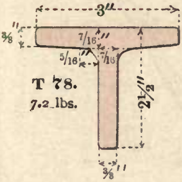


T 76.
9.8 lbs.

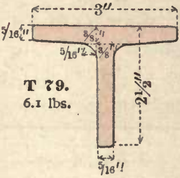


T 77.
8.5 lbs.

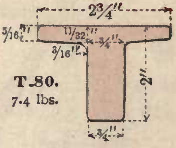
TEES WITH UNEQUAL LEGS.



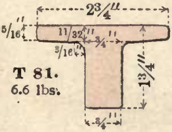
T 78.
7.2 lbs.



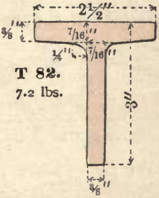
T 79.
6.1 lbs.



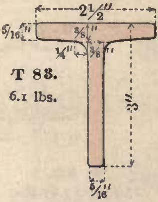
T 80.
7.4 lbs.



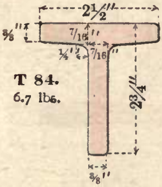
T 81.
6.6 lbs.



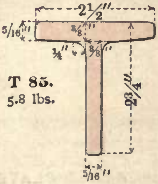
T 82.
7.2 lbs.



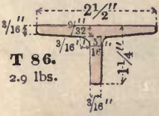
T 83.
6.1 lbs.



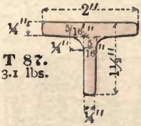
T 84.
6.7 lbs.



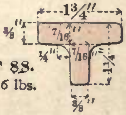
T 85.
5.8 lbs.



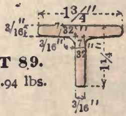
T 86.
2.9 lbs.



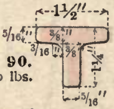
T 87.
3.1 lbs.



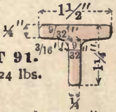
T 88.
3.6 lbs.



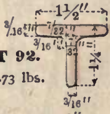
T 89.
1.94 lbs.



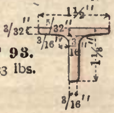
T 90.
3.0 lbs.



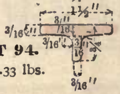
T 91.
2.24 lbs.



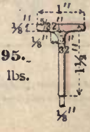
T 92.
1.73 lbs.



T 93.
1.33 lbs.



T 94.
1.33 lbs.

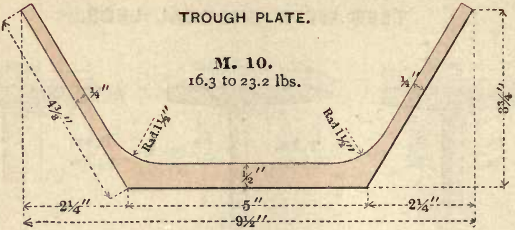


T 95.
1.12 lbs.

PLATES.

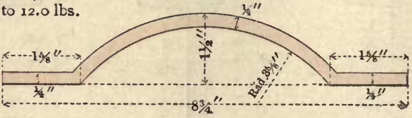
TROUGH PLATE.

M. 10.
16.3 to 23.2 lbs.

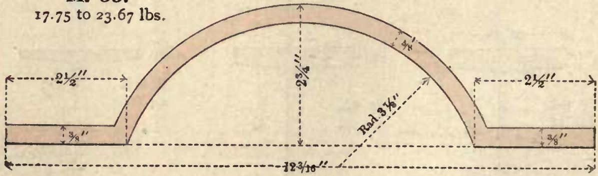


CORRUGATED PLATES.

M. 30.
8.1 to 12.0 lbs.

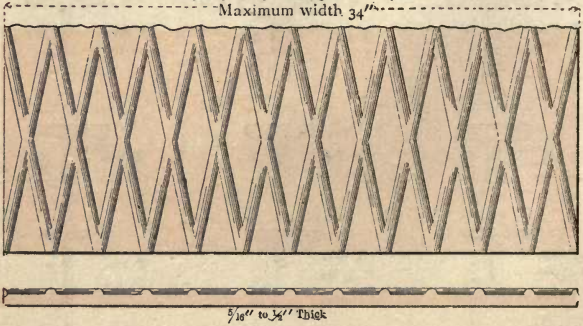


M. 33.
17.75 to 23.67 lbs.



CHECKERED PLATE.

M. 51.
Weight per sq. foot 13.8 to 21.4 lbs.



SIZES OF CARNEGIE BARS.

All dimensions given are in inches.

ROUNDS.

5/16, 3/8, 7/16, 1/2, 9/16, 5/8, 11/16, 47/64, 3/4, 13/16, 55/64, 7/8, 15/16, 1, 1 1/16, 1 1/8, 1 1/4, 1 5/16, 1 3/8, 1 7/16, 1 1/2, 1 9/16, 1 5/8, 1 3/4, 1 7/8, 2, 2 1/8, 2 1/4, 2 3/8, 2 1/2, 2 5/8, 2 3/4, 2 7/8, 3, 3 1/4, 3 1/2, 3 3/4, 4, 4 1/8, 4 1/4, 4 3/8, 4 1/2, 4 5/8, 4 3/4, 4 7/8, 5, 5 1/8, 5 1/4, 5 3/8, 5 1/2, 5 5/8, 5 3/4, 6, 6 1/4, 6 1/2, 6 3/4.

SQUARES.

5/16, 3/8, 7/16, 1/2, 9/16, 5/8, 11/16, 3/4, 13/16, 7/8, 15/16, 1, 1 1/16, 1 1/8, 1 3/16, 1 1/4, 1 5/16, 1 3/8, 1 7/16, 1 1/2, 1 9/16, 1 5/8, 1 11/16, 1 3/4, 1 13/16, 1 7/8, 1 15/16, 2, 2 1/8, 2 1/4, 2 3/8, 2 1/2, 2 5/8, 2 3/4, 2 7/8, 3, 3 1/4, 3 1/2, 4.

HALF-ROUNDS.

3/4, 7/8, 1, 1 1/8, 1 1/4, 1 1/2, 1 3/4, 2, 2 1/4, 2 1/2, 3, 4 1/2.

OVALS.

5/8 × 5/16, 3/4 × 3/8, 7/8 × 7/16

ROUND EDGE FLATS.

1 1/2 × 3/8, 1 1/2 × 1/2, 1 3/4 × 3/8, 1 3/4 × 1/2, 1 3/4 × 5/8, 1 7/8 × 3/8, 1 7/8 × 1/2, 1 7/8 × 5/8, 2 × 3/8, 2 × 1/2, 2 × 5/8, 2 1/4 × 3/8, 2 1/4 × 1/2, 2 1/4 × 5/8, 2 1/2 × 3/8, 2 1/2 × 1/2, 2 1/2 × 5/8, 2 3/4 × 3/8, 2 3/4 × 1/2, 2 3/4 × 5/8, 3 × 3/8, 3 × 1/2, 3 × 5/8, 3 × 3/4.

FLATS.

Width.	Thickness.	Width.	Thickness.	Width.	Thickness.
3/4	1/8 to 5/8	1 7/8	1/2 to 1 1/2	4	1/4 to 2
7/8	1/8 to 3/4	2	1/8 to 1 3/4	4 1/2	1/4 to 2
1	1/8 to 15/16	2 1/4	1/4 to 1 3/4	5	1/4 to 2
1 1/8	1/8 to 1	2 3/8	1/4 to 1 1/8	5 1/2	1/4 to 2
1 1/4	1/8 to 1 1/8	2 1/2	3/16 to 1 3/4	6	1/4 to 2
1 3/8	1/8 to 1 1/8	2 5/8	1/4 to 1 1/8	6 1/2	1/4 to 2
1 1/2	1/8 to 1 1/4	2 3/4	1/4 to 1 1/8	7	1/4 to 2
1 5/8	1/2 to 1 1/2	3	1/4 to 2	7 1/2	1/4 to 2
1 3/4	3/16 to 1 1/2	3 1/2	1/4 to 2	. .	. .

EXTREME LENGTHS IN INCHES OF RECTANGULAR PLATES ROLLED BY THE CARNEGIE STEEL CO., LIMITED.

Thickness, in Inches.	114 In. Wide.	108 In. Wide.	105 In. Wide.	100 In. Wide.	96 In. Wide.	90 In. Wide.	84 In. Wide.	80 In. Wide.
¼	. .	. .	120	150	180	200	225	245
5/16	. .	130	160	200	210	225	250	275
⅜	140	170	200	260	310	330	360	380
7/16	160	200	230	245	310	340	380	400
½	170	200	220	240	290	330	360	370
9/16	170	190	210	230	270	290	340	360
⅝	160	180	200	220	240	260	300	310
11/16	160	180	190	200	220	240	260	280
¾	160	180	190	200	210	220	250	280
13/16	150	170	180	190	200	215	245	260
⅞	140	160	170	180	190	205	220	230
1	130	150	160	170	180	195	215	230
1⅛	120	140	145	150	160	175	190	210
1¼	110	120	125	140	145	155	175	185

Thickness, in Inches.	76 In. Wide.	72 In. Wide.	68 In. Wide.	64 In. Wide.	56 In. Wide.	48 In. Wide.	36 In. Wide.	24 In. Wide.
¼	260	275	290	310	365	430	500	500
5/16	300	320	360	400	460	500	550	600
⅜	400	420	440	460	500	570	600	600
7/16	420	430	450	480	530	570	600	600
½	390	410	450	480	520	570	600	600
9/16	370	390	420	450	500	570	600	600
⅝	330	350	370	400	480	530	600	600
11/16	310	330	350	380	430	500	600	600
¾	300	320	340	360	410	480	540	600
13/16	280	300	320	340	380	450	540	600
⅞	260	270	300	320	360	430	540	600
1	240	250	270	290	330	380	500	540
1⅛	220	230	240	260	300	350	440	500
1¼	195	205	215	230	265	310	400	500

MINIMUM AND MAXIMUM WEIGHTS AND DIMENSIONS OF CARNEGIE I BEAMS.

Section Index.	Depth of Beam, in inches.	Weight per foot.		Flange width.		Web thickness.		Increase of web and flanges for each lb. increase of weight.	Page No. of section.
		Min.	Max.	Min.	Max.	Min.	Max.		
B 1	24.	80.00	100.00	6.95	7.20	.50	.75	.0123	1
B 2	20.	80.00	100.00	7.00	7.30	.60	.90	.015	2
B 3	20.	64.00	75.00	6.25	6.41	.50	.66	.015	2
B 4	15.	80.00	100.00	6.41	6.81	.77	1.17	.020	3
B 5	15.	60.00	75.00	6.04	6.34	.54	.84	.020	3
B 6	15.	50.00	55.00	5.75	5.85	.45	.55	.020	3
B 7	15.	41.00	45.00	5.50	5.58	.40	.48	.020	3
B 8	12.	40.00	56.67	5.50	5.91	.39	.80	.025	4
B 9	12.	32.00	36.00	5.25	5.35	.35	.45	.025	4
B10	10.	33.00	40.00	5.00	5.20	.37	.57	.029	4
B11	10.	25.00	30.00	4.74	4.88	.31	.45	.029	4
B13	9.	21.00	30.00	4.50	4.80	.27	.57	.033	4
B15	8.	18.00	25.00	4.25	4.51	.25	.51	.037	5
B17	7.	15.00	20.00	3.98	4.19	.21	.42	.042	5
B19	6.	13.00	18.00	3.50	3.74	.23	.47	.049	5
B21	5.	10.00	15.00	3.00	3.30	.22	.52	.059	5
B23	4.	7.00	10.00	2.59	2.81	.17	.39	.074	5
B77	3.	6.00	7.00	2.26	2.36	.20	.30	.098	5

MINIMUM AND MAXIMUM WEIGHTS AND DIMENSIONS OF CARNEGIE DECK BEAMS.

Section Index.	Depth of Beam, in inches.	Weight per foot.		Flange width.		Web thickness.		Increase of web and flanges for each lb. increase of weight.	Page No. of section.
		Min.	Max.	Min.	Max.	Min.	Max.		
B100	10.	27.23	35.70	5.25	5.50	.38	.63	.029	6
B101	9.	26.00	30.00	4.94	5.07	.44	.57	.033	6
B102	8.	20.15	24.48	5.00	5.16	.31	.47	.037	6
B103	7.	18 11	23.46	4.87	5.10	.31	.54	.042	6
B105	6.	15.30	18.36	4.38	4.53	.28	.43	049	6

WEIGHTS AND DIMENSIONS OF CARNEGIE BULB ANGLES.

Section Index.	Depth of Angle, in inches.	Weight per foot.	Flange width.	Web thickness.	Page No. of section.
B130	10	26.50	3.5	.48	7
B131	9	21.80	3.5	.44	7
B132	8	19.23	3.5	.41	7
B133	7	18.25	3.0	.44	7
B134	6	17.20	3.0	.50	7
B135	6	13.75	3.0	.38	7
B136	6	12.30	3.0	.31	7
B137	5	10.00	2.5	.31	7

MINIMUM AND MAXIMUM WEIGHTS AND DIMENSIONS OF CARNEGIE CHANNELS.

Section Index.	Depth of Channel, in inches.	Weight per foot.		Flange width.		Web thickness.		Increases of web and flanges for each lb. increase of weight.	Page No. of section.
		Min.	Max.	Min.	Max.	Min.	Max.		
C 1	15	33.00	55.00	3.400	3.840	.400	.840	.020	8
C20	13	31.50	52.00	4.000	4.460	.375	.840	.023	8
C 2	12	20.00	44.00	2.868	3.460	.268	.860	.025	8
C 3	10	16.50	33.00	2.665	3.150	.265	.750	.029	8
C 4	9	14.00	25.00	2.450	2.810	.250	.610	.033	8
C 5	8	11.00	22.00	2.205	2.610	.205	.610	.037	9
C 6	7	9.50	20.00	2.011	2.450	.211	.650	.042	9
C 7	6	8.00	16.00	1.895	2.288	.195	.588	.049	9
C 8	5	6.50	12.00	1.772	2.095	.172	.495	.059	9
C 9	4	5.50	8.00	1.670	1.854	.170	.354	.074	9
C72	3	5.00	6.00	1.550	1.650	.230	.330	.098	9

MINIMUM AND MAXIMUM WEIGHTS AND DIMENSIONS OF CARNEGIE EQUAL AND UNEQUAL FLANGE CAR TRUCK

CHANNELS.

Section Index.	Depth of Channel, in inches.	Weight per foot.		Flange width.		Web Thickness.		Increase of flange and web for each lb. increase of weight.	Page No. of Section.
		Min.	Max.	Min.	Max.	Min.	Max.		
C 20	13.0	31.50	52.0	4.00	4.46	.375	.84	.023	10
C 54	12.0	21.33	30.0	2.64	2.85	.31	.52	.025	10
C103	10.5	20.00	. .	Smaller. 2.50	Larger. 3.375	.375	. .	. .	10
C106	10.5	26.50	. .	2.50	3.375	.50	. .	. .	10

WEIGHTS AND DIMENSIONS OF CARNEGIE

SPECIAL Z-BARS.

Section Index.	Thickness of Metal.	SIZE, IN INCHES.			Weight per foot.	Page No. of Section.
		Flange.	Web.	Flange.		
Z13	3/8	3	6	3	14.5	13
Z14	3/8	2 1/2	5	3	12.4	13
Z15	3/8	2 1/2	4	3	11.1	13
Z16	3/8	2 1/2	3	3	10.0	13
Z17	5/16	2 1/2	3	3	8.4	13
Z18	1/8	9/16	1 1/8	1 3/8	1.3	13
Z19	. .	1 1/4 x 5/16	1 3/4 x 5/16	2 3/16 x 1/4	4.5	13

MINIMUM AND MAXIMUM WEIGHTS AND DIMENSIONS OF CARNEGIE
Z-BARS.

Section Index.	Thickness of Metal in inches	SIZE IN INCHES.			Weight per foot.	Page No. of Section.
		Flange.	Web.	Flange.		
Z 1	$\frac{3}{8}$	$3\frac{1}{2}$	6	$3\frac{1}{2}$	15.6	11
“	$\frac{7}{16}$	$3\frac{9}{16}$	$6\frac{1}{16}$	$3\frac{9}{16}$	18.3	. .
“	$\frac{1}{2}$	$3\frac{5}{8}$	$6\frac{1}{8}$	$3\frac{5}{8}$	21.0	. .
Z 2	$\frac{9}{16}$	$3\frac{1}{2}$	6	$3\frac{1}{2}$	22.7	11
“	$\frac{5}{8}$	$3\frac{9}{16}$	$6\frac{1}{16}$	$3\frac{9}{16}$	25.4	. .
“	$\frac{11}{16}$	$3\frac{5}{8}$	$6\frac{1}{8}$	$3\frac{5}{8}$	28.0	. .
Z 3	$\frac{3}{4}$	$3\frac{1}{2}$	6	$3\frac{1}{2}$	29.3	11
“	$\frac{13}{16}$	$3\frac{9}{16}$	$6\frac{1}{16}$	$3\frac{9}{16}$	32.0	. .
“	$\frac{7}{8}$	$3\frac{5}{8}$	$6\frac{1}{8}$	$3\frac{5}{8}$	34.6	. .
Z 4	$\frac{5}{16}$	$3\frac{1}{4}$	5	$3\frac{1}{4}$	11.6	11
“	$\frac{3}{8}$	$3\frac{5}{16}$	$5\frac{1}{16}$	$3\frac{5}{16}$	13.9	. .
“	$\frac{7}{16}$	$3\frac{3}{8}$	$5\frac{1}{8}$	$3\frac{3}{8}$	16.4	. .
Z 5	$\frac{1}{2}$	$3\frac{1}{4}$	5	$3\frac{1}{4}$	17.8	11
“	$\frac{9}{16}$	$3\frac{5}{16}$	$5\frac{1}{16}$	$3\frac{5}{16}$	20.2	. .
“	$\frac{5}{8}$	$3\frac{3}{8}$	$5\frac{1}{8}$	$3\frac{3}{8}$	22.6	
Z 6	$\frac{11}{16}$	$3\frac{1}{4}$	5	$3\frac{1}{4}$	23.7	11
“	$\frac{3}{4}$	$3\frac{5}{16}$	$5\frac{1}{16}$	$3\frac{5}{16}$	26.0	. .
“	$\frac{13}{16}$	$3\frac{3}{8}$	$5\frac{1}{8}$	$3\frac{3}{8}$	28.3	. .
Z 7	$\frac{1}{4}$	$3\frac{1}{16}$	4	$3\frac{1}{16}$	8.2	12
“	$\frac{5}{16}$	$3\frac{1}{8}$	$4\frac{1}{16}$	$3\frac{1}{8}$	10.3	. .
“	$\frac{3}{8}$	$3\frac{3}{16}$	$4\frac{1}{8}$	$3\frac{3}{16}$	12.4	.
Z 8	$\frac{7}{16}$	$3\frac{1}{16}$	4	$3\frac{1}{16}$	13.8	12
“	$\frac{1}{2}$	$3\frac{1}{8}$	$4\frac{1}{16}$	$3\frac{1}{8}$	15.8	. .
“	$\frac{9}{16}$	$3\frac{3}{16}$	$4\frac{1}{8}$	$3\frac{3}{16}$	17.9	. .
Z 9	$\frac{5}{8}$	$3\frac{1}{16}$	4	$3\frac{1}{16}$	18.9	12
“	$\frac{11}{16}$	$3\frac{1}{8}$	$4\frac{1}{16}$	$3\frac{1}{8}$	20.9	. .
“	$\frac{3}{4}$	$3\frac{3}{16}$	$4\frac{1}{8}$	$3\frac{3}{16}$	22.9	. .
Z10	$\frac{1}{4}$	$2\frac{11}{16}$	3	$2\frac{11}{16}$	6.7	12
“	$\frac{5}{16}$	$2\frac{3}{4}$	$3\frac{1}{16}$	$2\frac{3}{4}$	8.4	
Z11	$\frac{3}{8}$	$2\frac{11}{16}$	3	$2\frac{11}{16}$	9.7	12
“	$\frac{7}{16}$	$2\frac{3}{4}$	$3\frac{1}{16}$	$2\frac{3}{4}$	11.4	. .
Z12	$\frac{1}{2}$	$2\frac{11}{16}$	3	$2\frac{11}{16}$	12.5	12
“	$\frac{9}{16}$	$2\frac{3}{4}$	$3\frac{1}{16}$	$2\frac{3}{4}$	14.2	. .

MINIMUM AND MAXIMUM WEIGHTS AND DIMENSIONS OF CARNEGIE ANGLES.

EQUAL LEGS.

Section Index.	Thickness of Metal, in inches.	Size, in inches.	Weight per foot.	Page No. of Section.	Section Index.	Thickness of Metal, in inches.	Size, in inches.	Weight per foot.	Page No. of Section.
A 1	7/8	6 x6	33.1	.	A36	1/2	3 x3	*9.4	15
A 2	13/16	6 x6	30.9	.	A37	7/16	3 x3	8.3	15
*A 3	3/4	6 x6	28.7	14	*A38	3/8	3 x3	7.2	15
A 4	11/16	6 x6	26.5	.	A39	5/16	3 x3	6.1	.
A 5	5/8	6 x6	24.2	.	*A40	1/4	3 x3	4.9	15
A 6	9/16	6 x6	21.9	.	A41	1/2	2¾x2¾	8.5	.
A 7	1/2	6 x6	19.6	.	A42	7/16	2¾x2¾	7.6	.
*A 8	7/16	6 x6	17.2	14	*A43	3/8	2¾x2¾	6.6	15
A 9	7/8	5 x5	27.2	.	A44	5/16	2¾x2¾	5.5	.
A10	13/16	5 x5	25.4	.	*A45	1/4	2¾x2¾	4.5	15
A11	3/4	5 x5	23.6	.	A46	1/2	2½x2½	7.7	.
*A12	11/16	5 x5	21.8	14	A47	7/16	2½x2½	6.8	.
A13	5/8	5 x5	*20.0	14	*A48	3/8	2½x2½	5.9	16
A14	9/16	5 x5	18.1	.	A49	5/16	2½x2½	5.0	.
*A15	1/2	5 x5	16.2	14	*A50	1/4	2½x2½	4.1	16
A16	7/16	5 x5	14.3	.	A51	1/2	2¼x2¼	6.8	.
*A17	3/8	5 x5	12.3	14	A52	7/16	2¼x2¼	6.1	.
A18	13/16	4 x4	19.9	.	*A53	3/8	2¼x2¼	5.3	16
A19	3/4	4 x4	18.5	.	A54	5/16	2¼x2¼	4.5	.
*A20	11/16	4 x4	17.1	15	*A55	1/4	2¼x2¼	3.7	16
A21	5/8	4 x4	*15.7	15	A56	7/16	2 x2	5.3	.
A22	9/16	4 x4	14.3	.	A57	3/8	2 x2	4.7	.
*A23	1/2	4 x4	12.8	15	*A58	5/16	2 x2	4.0	16
A24	7/16	4 x4	11.3	.	A59	1/4	2 x2	3.2	.
*A25	3/8	4 x4	9.8	15	*A60	3/16	2 x2	2.5	16
*A90	5/16	4 x4	8.2	.	A61	7/16	1¾x1¾	4.6	.
A26	13/16	3½x3½	17.1	.	A62	3/8	1¾x1¾	4.0	.
A27	3/4	3½x3½	16.0	.	A63	5/16	1¾x1¾	3.4	.
*A28	11/16	3½x3½	14.8	15	*A64	1/4	1¾x1¾	2.8	16
A29	5/8	3½x3½	13.6	.	*A65	3/16	1¾x1¾	2.1	16
A30	9/16	3½x3½	12.3	.	A66	3/8	1½x1½	3.4	.
*A31	1/2	3½x3½	11.1	15	*A67	5/16	1½x1½	2.9	16
A32	7/16	3½x3½	9.8	.	*A68	1/4	1½x1½	2.4	16
*A33	3/8	3½x3½	8.5	15	*A69	3/16	1½x1½	1.8	16
A34	5/8	3 x3	11.4	.	A70	5/16	1¼x1¼	2.4	.
*A35	9/16	3 x3	10.4	15	*A71	1/4	1¼x1¼	1.9	16

Angles marked thus * have finishing passes.

ANGLES—EQUAL LEGS.—Continued.

Section Index.	Thickness of Metal, in inches.	Size, in inches.	Weight per foot.	Page No. of Section.	Section Index.	Thickness of Metal, in inches.	Size, in inches.	Weight per foot.	Page No. of Section.
*A72	$\frac{3}{16}$	1¼x1¼	1.5	16	*A79	$\frac{3}{16}$	1 x1	1.2	16
*A73	⅛	1¼x1¼	1.0	16	*A80	⅛	1 x1	0.8	16
A74	$\frac{5}{16}$	1⅛x1⅛	2.1	.	*A81	$\frac{3}{16}$	⅞x ⅞	1.0	16
*A75	¼	1⅛x1⅛	1.7	16	*A82	⅛	⅞x ⅞	0.7	16
*A76	$\frac{3}{16}$	1⅛x1⅛	1.3	16	*A83	$\frac{3}{16}$	¾x ¾	0.8	16
*A77	⅛	1⅛x1⅛	0.9	16	*A84	⅛	¾x ¾	0.6	16
*A78	¼	1 x1	1.5	16	*A85	⅛	⅝x ⅝	0.5	16

Angles marked thus * have finishing passes.

SPECIAL ANGLES.

Section Index.	Thickness of Metal, in inches.	Size, in inches.	Weight per foot.	Page No. of Section.	Section Index.	Thickness of Metal, in inches.	Size, in inches.	Weight per foot.	Page No. of Section.
A450	$\frac{13}{16}$	3 x3	14.4	.	A462	$\frac{7}{16}$	2½x2½	7.1	.
A451	¾	3 x3	13.4	.	*A463	⅜	2½x2½	6.1	24
*A452	$\frac{11}{16}$	3 x3	12.4	24	A464	½	3¼x2	8.2	.
A453	⅝	3 x3	11.4	.	A465	$\frac{7}{16}$	3¼x2	7.1	.
*A454	$\frac{9}{16}$	3 x3	10.4	24	*A466	⅜	3¼x2	6.1	24
A455	$\frac{11}{16}$	2½x2½	10.1	.	A467	$\frac{7}{16}$	3 x3	8.4	.
A456	⅝	2½x2½	9.3	.	A468	⅜	3 x3	7.2	..
*A457	$\frac{9}{16}$	2½x2½	8.5	24	*A469	$\frac{5}{16}$	3 x3	6.1	24
A458	½	2½x2½	7.7	.	*A470	¼	$2\frac{15}{16}$x2¼	4.2	24
*A459	$\frac{7}{16}$	2½x2½	6.8	24	*A471	¼	2¼x2¼	3.5	24
*A460	¾x½	2½x2¼	8.7	24	*A475	½x ⅜	3¼x ⅞	4.9	24
A461	½	2½x2½	8.2	.	*A476	½x ⅜	3¼x ¾	4.6	24

Angles marked thus * have finishing passes.

A450 to A459 known as "COVER ANGLES."

A461 to A469 known as "OBTUSE ANGLES."

A470 and A471 known as "SAFE ANGLES."

A475 and A476 known as "HALF TEES."

MINIMUM AND MAXIMUM WEIGHTS AND DIMENSIONS OF CARNEGIE ANGLES.

UNEQUAL LEGS.

Section Index.	Thickness of Metal, in inches.	Size, in inches.	Weight per foot.	Page No. of Section.
A150	1	7x3½	32.3	.
A151	$\frac{15}{16}$	7x3½	30.5	.
A152	⅞	7x3½	28.7	.
A153	$\frac{13}{16}$	7x3½	26.8	.
*A154	¾	7x3½	24.9	17
A155	$\frac{11}{16}$	7x3½	23.0	.
A156	⅝	7x3½	21.0	.
*A157	$\frac{9}{16}$	7x3½	19.0	17
A158	½	7x3½	17.0	.
*A159	$\frac{7}{16}$	7x3½	15.0	17
A160	⅞	6x4	27.2	.
A161	$\frac{13}{16}$	6x4	25.4	.
*A162	¾	6x4	23.6	17
A163	$\frac{11}{16}$	6x4	21.8	.
A164	⅝	6x4	20.0	.
A165	$\frac{9}{16}$	6x4	18.1	.
*A166	½	6x4	16.2	17
A167	$\frac{7}{16}$	6x4	14.3	.
*A168	⅜	6x4	12.3	17
A169	⅞	6x3½	25.7	.
A170	$\frac{13}{16}$	6x3½	24.0	.
*A171	¾	6x3½	22.3	18
A172	$\frac{11}{16}$	6x3½	20.6	.
A173	⅝	6x3½	18.9	.
A174	$\frac{9}{16}$	6x3½	17.1	.
*A175	½	6x3½	15.3	18
A176	$\frac{7}{16}$	6x3½	13.5	.
*A177	⅜	6x3½	11.7	18
A178	⅞	5x4	24.2	.
A179	$\frac{13}{16}$	5x4	22.6	.
A180	¾	5x4	*21.1	18
*A181	$\frac{11}{16}$	5x4	19.5	18
A182	⅝	5x4	17.8	.
A183	$\frac{9}{16}$	5x4	16.2	.

Section Index.	Thickness of Metal, in inches.	Size, in inches.	Weight per foot.	Page No. of Section.
*A184	½	5 x4	14.5	18
A185	$\frac{7}{16}$	5 x4	12.8	.
*A186	⅜	5 x4	11.0	18
A187	⅞	5 x3½	22.7	.
A188	$\frac{13}{16}$	5 x3½	21.3	.
*A189	¾	5 x3½	19.8	19
*A190	$\frac{11}{16}$	5 x3½	18.3	19
A191	⅝	5 x3½	16.8	.
A192	$\frac{9}{16}$	5 x3½	15.2	.
*A193	½	5 x3½	13.6	19
A194	$\frac{7}{16}$	5 x3½	12.0	.
*A195	⅜	5 x3½	10.4	19
A196	$\frac{13}{16}$	5 x3	19.9	.
A197	¾	5 x3	18.5	.
*A198	$\frac{11}{16}$	5 x3	17.1	19
A199	⅝	5 x3	15.7	.
A200	$\frac{9}{16}$	5 x3	14.2	.
*A201	½	5 x3	12.8	19
A202	$\frac{7}{16}$	5 x3	11.3	.
*A203	⅜	5 x3	9.8	19
*A280	$\frac{5}{16}$	5 x3	8.2	19
A204	$\frac{13}{16}$	4½x3	18.5	.
A205	¾	4½x3	17.2	.
*A206	$\frac{11}{16}$	4½x3	15.9	19
A207	⅝	4½x3	14.6	.
A208	$\frac{9}{16}$	4½x3	13.3	.
*A209	½	4½x3	11.9	19
A210	$\frac{7}{16}$	4½x3	10.5	.
*A211	⅜	4½x3	9.1	19
A212	$\frac{13}{16}$	4 x3½	18.5	.
A213	¾	4 x3½	17.2	.
*A214	$\frac{11}{16}$	4 x3½	15.9	19
A215	⅝	4 x3½	14.6	.
A216	$\frac{9}{16}$	4 x3½	13.3	

Angles marked thus * have finishing passes.

MINIMUM AND MAXIMUM WEIGHTS AND DIMENSIONS OF CARNEGIE ANGLES.

UNEQUAL LEGS.—Continued.

Section Index.	Thickness of Metal, in inches.	Size, in inches.	Weight per foot.	Page No. of Section.
*A217	½	4 x3½	11.9	19
A218	7/16	4 x3½	10.5	.
*A219	⅜	4 x3½	9.1	19
A220	13/16	4 x3	17.1	.
A221	¾	4 x3	16.0	.
*A222	11/16	4 x3	14.8	19
A223	⅝	4 x3	13.6	.
A224	9/16	4 x3	12.3	.
*A225	½	4 x3	11.1	20
A226	7/16	4 x3	9.8	.
A227	⅜	4 x3	8.5	.
*A228	5/16	4 x3	7.1	20
A229	13/16	3½x3	15.7	.
A230	¾	3½x3	14.7	.
*A231	11/16	3½x3	13.6	20
A232	⅝	3½x3	12.5	.
A233	9/16	3½x3	11.4	.
*A234	½	3½x3	10.2	20
A235	7/16	3½x3	9.1	.
A236	⅜	3½x3	7.8	.
*A237	5/16	3½x3	6.6	20
A238	11/16	3½x2½	12.4	.
A239	⅝	3½x2½	11.4	.
A240	9/16	3½x2½	*10.4	20
A241	½	3½x2½	9.4	.
A242	7/16	3½x2½	8.3	20
A243	⅜	3½x2½	*7.2	20
A244	5/16	3½x2½	6.1	.
*A245	¼	3½x2½	4.9	20
A246	9/16	3¼x2	9.0	.
A247	½	3¼x2	8.1	.
*A248	7/16	3¼x2	7.2	20
A249	⅜	3¼x2	6.2	.
A250	5/16	3¼x2	5.3	.
*A251	¼	3¼x2	4.3	20
A252	9/16	3 x2½	9.5	.
A253	½	3 x2½	8.5	.
*A254	7/16	3 x2½	7.6	20
A255	⅜	3 x2½	6.6	.
A256	5/16	3 x2½	5.5	.
*A257	¼	3 x2½	4.5	21
A258	½	3 x2	7.7	.
*A259	7/16	3 x2	6.8	21
A260	⅜	3 x2	5.9	.
A261	5/16	3 x2	5.0	.
*A262	¼	3 x2	4.1	21
*A263	7/32	3 x2	3.6	21
A264	½	2½x2	6.8	.
A265	7/16	2½x2	6.1	.
*A266	⅜	2½x2	5.3	21
*A267	5/16	2½x2	4.5	21
*A268	¼	2½x2	3.7	21
*A269	3/16	2½x2	2.8	21
A270	½	2¼x1½	5.5	.
A271	7/16	2¼x1½	5.0	.
*A272	⅜	2¼x1½	4.3	21
*A273	5/16	2¼x1½	3.7	21
*A274	¼	2¼x1½	3.0	21
*A275	3/16	2¼x1½	2.3	21
*A276	¼	2 x1⅜	2.7	21
*A277	3/16	2 x1⅜	2.1	21
A278	7/32	1⅜x1	1.6	.
*A279	⅛	1⅜x1	1.0	21

Angles marked thus * have finishing passes.

MINIMUM AND MAXIMUM WEIGHTS AND DIMENSIONS OF CARNEGIE ANGLES.

SQUARE ROOT.

Section Index.	Thickness of Metal, in inches.	Size, in inches.	Weight per foot.	Page No. of Section.
A350	$\frac{3}{4}$	4 x4	18.5	.
A351	$\frac{11}{16}$	4 x4	17.1	.
*A352	$\frac{5}{8}$	4 x4	15.7	22
A353	$\frac{9}{16}$	4 x4	14.3	.
*A354	$\frac{1}{2}$	4 x4	12.8	22
A355	$\frac{7}{16}$	4 x4	11.3	.
*A356	$\frac{3}{8}$	4 x4	9.7	22
*A357	$\frac{3}{4}$	$3\frac{1}{2}$x$3\frac{1}{2}$	16.0	22
A358	$\frac{11}{16}$	$3\frac{1}{2}$x$3\frac{1}{2}$	14.8	.
A359	$\frac{5}{8}$	$3\frac{1}{2}$x$3\frac{1}{2}$	13.6	.
A360	$\frac{9}{16}$	$3\frac{1}{2}$x$3\frac{1}{2}$	12.3	.
*A361	$\frac{1}{2}$	$3\frac{1}{2}$x$3\frac{1}{2}$	11.0	22
A362	$\frac{7}{16}$	$3\frac{1}{2}$x$3\frac{1}{2}$	9.8	.
*A363	$\frac{3}{8}$	$3\frac{1}{2}$x$3\frac{1}{2}$	8.5	22
A364	$\frac{5}{8}$	3 x3	11.4	.
A365	$\frac{9}{16}$	3 x3	10.4	.
A366	$\frac{1}{2}$	3 x3	9.4	.
A367	$\frac{7}{16}$	3 x3	8.3	.
A368	$\frac{3}{8}$	3 x3	7.2	.
*A369	$\frac{5}{16}$	3 x3	6.0	22
*A370	$\frac{1}{4}$	3 x3	4.9	22
A371	$\frac{1}{2}$	$2\frac{3}{4}$x$2\frac{3}{4}$	8.6	.
A372	$\frac{7}{16}$	$2\frac{3}{4}$x$2\frac{3}{4}$	7.6	.
A373	$\frac{3}{8}$	$2\frac{3}{4}$x$2\frac{3}{4}$	6.6	.
*A374	$\frac{5}{16}$	$2\frac{3}{4}$x$2\frac{3}{4}$	5.5	22
A375	$\frac{1}{2}$	$2\frac{1}{2}$x$2\frac{1}{2}$	7.7	.
A376	$\frac{7}{16}$	$2\frac{1}{2}$x$2\frac{1}{2}$	6.8	.
A377	$\frac{3}{8}$	$2\frac{1}{2}$x$2\frac{1}{2}$	5.9	.
A378	$\frac{5}{16}$	$2\frac{1}{2}$x$2\frac{1}{2}$	5.0	22
*A379	$\frac{1}{4}$	$2\frac{1}{2}$x$2\frac{1}{2}$	4.1	22
A380	$\frac{3}{8}$	$2\frac{1}{2}$x$2\frac{1}{4}$	5.6	.
A381	$\frac{5}{16}$	$2\frac{1}{2}$x$2\frac{1}{4}$	4.7	.
*A382	$\frac{1}{4}$	$2\frac{1}{2}$x$2\frac{1}{4}$	3.9	22
A383	$\frac{1}{2}$	$2\frac{1}{4}$x$2\frac{1}{4}$	6.8	.
A384	$\frac{7}{16}$	$2\frac{1}{4}$x$2\frac{1}{4}$	6.0	.

Section Index.	Thickness of Metal, in inches.	Size, in inches.	Weight per foot.	Page No. of Section.
A385	$\frac{3}{8}$	$2\frac{1}{4}$x$2\frac{1}{4}$	5.3	22
A386	$\frac{5}{16}$	$2\frac{1}{4}$x$2\frac{1}{4}$	4.5	22
*A387	$\frac{1}{4}$	$2\frac{1}{4}$x$2\frac{1}{4}$	3.6	22
A388	$\frac{7}{16}$	2 x2	5.3	.
*A389	$\frac{3}{8}$	2 x2	4.7	23
*A390	$\frac{5}{16}$	2 x2	3.9	23
*A391	$\frac{1}{4}$	2 x2	3.2	23
A392	$\frac{7}{16}$	$1\frac{3}{4}$x$1\frac{3}{4}$	4.5	.
A393	$\frac{3}{8}$	$1\frac{3}{4}$x$1\frac{3}{4}$	4.0	.
A394	$\frac{5}{16}$	$1\frac{3}{4}$x$1\frac{3}{4}$	3.4	.
*A395	$\frac{1}{4}$	$1\frac{3}{4}$x$1\frac{3}{4}$	2.8	23
A396	$\frac{3}{8}$	$1\frac{1}{2}$x$1\frac{1}{2}$	3.4	.
A397	$\frac{5}{16}$	$1\frac{1}{2}$x$1\frac{1}{2}$	2.9	.
*A398	$\frac{1}{4}$	$1\frac{1}{2}$x$1\frac{1}{2}$	2.4	23
*A399	$\frac{3}{16}$	$1\frac{1}{2}$x$1\frac{1}{2}$	1.9	23
A400	$\frac{5}{16}$	$1\frac{1}{4}$x$1\frac{1}{4}$	2.4	.
*A401	$\frac{1}{4}$	$1\frac{1}{4}$x$1\frac{1}{4}$	2.0	23
*A402	$\frac{3}{16}$	$1\frac{1}{4}$x$1\frac{1}{4}$	1.5	23
*A403	$\frac{1}{8}$	$1\frac{1}{4}$x$1\frac{1}{4}$	1.0	23
*A404	$\frac{1}{4}$	$1\frac{3}{8}$x $\frac{7}{8}$	1.8	23
*A405	$\frac{1}{8}$	$1\frac{3}{8}$x $\frac{7}{8}$	0.9	23
*A406	$\frac{1}{4}$	$1\frac{1}{8}$x$1\frac{1}{8}$	1.7	23
*A407	$\frac{3}{16}$	$1\frac{1}{8}$x$1\frac{1}{8}$	1.3	23
*A408	$\frac{1}{8}$	$1\frac{1}{8}$x$1\frac{1}{8}$	0.9	23
*A430	$\frac{3}{16}$	$1\frac{1}{16}$x $\frac{13}{16}$	1.1	23
*A409	$\frac{1}{4}$	1 x1	1.5	23
*A410	$\frac{3}{16}$	1 x1	1.1	23
*A411	$\frac{1}{8}$	1 x1	0.8	23
A412	$\frac{3}{16}$	$\frac{7}{8}$x $\frac{7}{8}$	1.0	.
*A413	$\frac{1}{8}$	$\frac{7}{8}$x $\frac{7}{8}$	0.7	23
*A414	$\frac{3}{16}$	$\frac{3}{4}$x $\frac{3}{4}$	0.8	23
*A415	$\frac{1}{8}$	$\frac{3}{4}$x $\frac{3}{4}$	0.6	23
*A416	$\frac{3}{32}$	$\frac{5}{8}$x $\frac{3}{8}$	0.3	23

Angles marked thus * have finishing passes.

WEIGHTS AND DIMENSIONS OF CARNEGIE TEES.

EQUAL LEGS.

Section Index.	Size, in Inches.		Thickness of Metal, in Inches.		Weight per foot.	Page No. of Section.
	Flange.	Stem.	Flange.	Stem.		
T 1	4	4	½ to $\frac{9}{16}$	½ to $\frac{9}{16}$	13.7	25
T 2	4	4	⅜ to $\frac{7}{16}$	⅜ to $\frac{7}{16}$	10.9	25
T 3	3½	3½	½ to $\frac{9}{16}$	½ to $\frac{9}{16}$	11.7	25
T 4	3½	3½	⅜ to $\frac{7}{16}$	⅜ to $\frac{7}{16}$	9.2	25
T 5	3½	3½	$\frac{17}{64}$ to $\frac{21}{64}$	$\frac{17}{64}$ to $\frac{21}{64}$	6.8	25
T 6	3	3	½ to $\frac{9}{16}$	½ to $\frac{9}{16}$	10.0	25
T 7	3	3	$\frac{7}{16}$ to ½	$\frac{7}{16}$ to ½	9.1	25
T 8	3	3	⅜ to $\frac{7}{16}$	⅜ to $\frac{7}{16}$	7.8	25
T 9	3	3	$\frac{5}{16}$ to ⅜	$\frac{5}{16}$ to ⅜	6.6	25
T10	2½	2½	⅜ to $\frac{7}{16}$	⅜ to $\frac{7}{16}$	6.4	25
T11	2½	2½	$\frac{5}{16}$ to ⅜	$\frac{5}{16}$ to ⅜	5.5	25
T12	2¼	2¼	$\frac{5}{16}$ to ⅜	$\frac{5}{16}$ to ⅜	4.9	25
T13	2¼	2¼	¼ to $\frac{5}{16}$	¼ to $\frac{5}{16}$	4.1	25
T14	2	2	$\frac{5}{16}$ to ⅜	$\frac{5}{16}$ to ⅜	4.3	25
T15	2	2	¼ to $\frac{5}{16}$	¼ to $\frac{5}{16}$	3.7	26
T16	1¾	1¾	¼ to $\frac{5}{16}$	¼ to $\frac{5}{16}$	3.1	26
T17	1½	1½	¼ to $\frac{9}{32}$	¼ to $\frac{9}{32}$	2.6	26
T18	1½	1½	$\frac{3}{16}$ to $\frac{7}{32}$	$\frac{3}{16}$ to $\frac{7}{32}$	1.84	26
T19	1¼	1¼	¼ to $\frac{9}{32}$	¼ to $\frac{9}{32}$	2.04	26
T20	1¼	1¼	$\frac{3}{16}$ to $\frac{7}{32}$	$\frac{3}{16}$ to $\frac{7}{32}$	1.53	26
T21	1	1	$\frac{3}{16}$ to $\frac{7}{32}$	$\frac{3}{16}$ to $\frac{7}{32}$	1.23	26
T22	1	1	⅛ to $\frac{5}{32}$	⅛ to $\frac{5}{32}$	0.87	26

WEIGHTS AND DIMENSIONS OF CARNEGIE TEES.

UNEQUAL LEGS.

Section Index.	Size, in Inches.		Thickness of Metal, in Inches.		Weight per foot.	Page No. of Section.
	Flange.	Stem.	Flange.	Stem.		
T50	5	3	$\frac{1}{2}$ to $\frac{9}{16}$	$\frac{13}{32}$ to $\frac{5}{8}$	13.6	27
T51	5	$2\frac{1}{2}$	$\frac{3}{8}$ to $\frac{7}{16}$	$\frac{7}{16}$ to $\frac{21}{32}$	11.0	27
T52	$4\frac{1}{2}$	$3\frac{1}{2}$	$\frac{7}{16}$ to $\frac{9}{16}$	$\frac{11}{16}$ to $\frac{7}{8}$	15.8	27
T53	$4\frac{1}{2}$	3	$\frac{5}{16}$ to $\frac{3}{8}$	$\frac{5}{16}$ to $\frac{3}{8}$	8.5	27
T54	$4\frac{1}{2}$	3	$\frac{3}{8}$ to $\frac{7}{16}$	$\frac{3}{8}$ to $\frac{7}{16}$	10.0	27
T55	$4\frac{1}{2}$	$2\frac{1}{2}$	$\frac{5}{16}$ to $\frac{3}{8}$	$\frac{5}{16}$ to $\frac{3}{8}$	8.0	27
T56	$4\frac{1}{2}$	$2\frac{1}{2}$	$\frac{3}{8}$ to $\frac{7}{16}$	$\frac{3}{8}$ to $\frac{7}{16}$	9.3	27
T57	4	5	$\frac{1}{2}$ to $\frac{9}{16}$	$\frac{1}{2}$ to $\frac{9}{16}$	15.6	27
T58	4	5	$\frac{3}{8}$ to $\frac{7}{16}$	$\frac{3}{8}$ to $\frac{7}{16}$	12.0	28
T59	4	$4\frac{1}{2}$	$\frac{1}{2}$ to $\frac{9}{16}$	$\frac{1}{2}$ to $\frac{9}{16}$	14.6	28
T60	4	$4\frac{1}{2}$	$\frac{3}{8}$ to $\frac{7}{16}$	$\frac{3}{8}$ to $\frac{7}{16}$	11.4	28
T61	4	3	$\frac{3}{8}$ to $\frac{7}{16}$	$\frac{3}{8}$ to $\frac{7}{16}$	9.3	28
T62	4	$2\frac{1}{2}$	$\frac{3}{8}$ to $\frac{7}{16}$	$\frac{3}{8}$ to $\frac{7}{16}$	8.6	28
T63	4	$2\frac{1}{2}$	$\frac{5}{16}$ to $\frac{3}{8}$	$\frac{5}{16}$ to $\frac{3}{8}$	7.3	28
T64	4	2	$\frac{3}{8}$ to $\frac{7}{16}$	$\frac{3}{8}$ to $\frac{7}{16}$	7.9	28
T65	4	2	$\frac{5}{16}$ to $\frac{3}{8}$	$\frac{5}{16}$ to $\frac{3}{8}$	6.6	28
T66	$3\frac{1}{2}$	4	$\frac{1}{2}$ to $\frac{9}{16}$	$\frac{1}{2}$ to $\frac{9}{16}$	12.8	29
T67	$3\frac{1}{2}$	4	$\frac{3}{8}$ to $\frac{7}{16}$	$\frac{3}{8}$ to $\frac{7}{16}$	9.9	29
T68	$3\frac{1}{2}$	3	$\frac{7}{16}$ to $\frac{1}{2}$	$\frac{11}{16}$	11.73	29
T69	$3\frac{1}{2}$	3	$\frac{1}{2}$ to $\frac{9}{16}$	$\frac{1}{2}$ to $\frac{9}{16}$	10.9	29
T70	$3\frac{1}{2}$	3	$\frac{3}{8}$ to $\frac{7}{16}$	$\frac{3}{8}$ to $\frac{7}{16}$	8.5	29
T71	$3\frac{1}{2}$	3	$\frac{5}{16}$ to $\frac{3}{8}$	$\frac{3}{8}$	7.8	29
T72	3	4	$\frac{1}{2}$ to $\frac{9}{16}$	$\frac{1}{2}$ to $\frac{9}{16}$	11.8	29
T73	3	4	$\frac{7}{16}$ to $\frac{1}{2}$	$\frac{7}{16}$ to $\frac{1}{2}$	10.6	29

T50 can also be rolled 11.0
T63 " " " " 5.8

WEIGHTS AND DIMENSIONS OF CARNEGIE TEES.

UNEQUAL LEGS.—Continued.

Section Index.	SIZE, IN INCHES.		THICKNESS OF METAL, IN INCHES.		Weight per foot.	Page No. of Section.
	Flange.	Stem.	Flange.	Stem.		
T74	3	4	3/8 to 7/16	3/8 to 7/16	9.3	29
T75	3	3½	½ to 9/16	½ to 9/16	10.9	29
T76	3	3½	7/16 to ½	7/16 to ½	9.8	29
T77	3	3½	3/8 to 7/16	3/8 to 7/16	8.5	29
T78	3	2½	3/8 to 7/16	3/8 to 7/16	7.2	30
T79	3	2½	5/16 to 3/8	5/16 to 3/8	6.1	30
T80	2¾	2	5/16 to 11/32	¾	7.4	30
T81	2¾	1¾	5/16 to 11/32	¾	6.6	30
T82	2½	3	3/8 to 7/16	3/8 to 7/16	7.2	30
T83	2½	3	5/16 to 3/8	5/16 to 3/8	6.1	30
T84	2½	2¾	3/8 to 7/16	3/8 to 7/16	6.7	30
T85	2½	2¾	5/16 to 3/8	5/16 to 3/8	5.8	30
T86	2½	1¼	3/16 to 9/32	3/16 to 5/16	2.9	30
T87	2	1½	¼ to 5/16	¼ to 5/16	3.1	30
T88	1¾	1¼	3/8 to 7/16	3/8 to 7/16	3.6	30
T89	1¾	1¼	3/16 to 7/32	3/16 to 7/32	1.94	30
T90	1½	1¼	5/16 to 3/8	5/16 to 3/8	3.0	30
T91	1½	1¼	¼ to 9/32	¼ to 9/32	2.24	30
T92	1½	1¼	3/16 to 7/32	3/16 to 7/32	1.73	30
T93	1½	1⅛	3/32 to 5/32	3/16	1.33	30
T94	1½	¾	3/16	3/16	1.33	30
T95	1	1½	⅛ to 5/32	⅛ to 5/32	1.12	30

WEIGHTS AND DIMENSIONS OF CARNEGIE MISCELLANEOUS SHAPES.

Section Index.	Designation of Shape.	Size, in inches.	Thickness of Metal, in inches.	Weight per foot.	Page No. of Section.
M10	Trough Plate,	$9\frac{1}{2}\times3\frac{3}{4}$	$\frac{1}{2}$	16.32	31
M11	"	$9\frac{1}{2}\times3\frac{3}{4}$	$\frac{9}{16}$	18.02	. .
M12	"	$9\frac{1}{2}\times3\frac{3}{4}$	$\frac{5}{8}$	19.72	. .
M13	"	$9\frac{1}{2}\times3\frac{3}{4}$	$\frac{11}{16}$	21.42	. .
M14	"	$9\frac{1}{2}\times3\frac{3}{4}$	$\frac{3}{4}$	23.15	. .
M30	Corrugated Plate,	$8\frac{3}{4}\times1\frac{1}{2}$	$\frac{1}{4}$	8.06	31
M31	"	$8\frac{3}{4}\times1\frac{1}{2}$	$\frac{5}{16}$	10.10	. .
M32	"	$8\frac{3}{4}\times1\frac{1}{2}$	$\frac{3}{8}$	12.04	. .
M33	"	$12\frac{3}{16}\times2\frac{3}{4}$	$\frac{3}{8}$	17.75	31
M34	"	$12\frac{3}{16}\times2\frac{3}{4}$	$\frac{7}{16}$	20.71	. .
M35	"	$12\frac{3}{16}\times2\frac{3}{4}$	$\frac{1}{2}$	23.67	. .
		Width.		Per Square Ft.	
M51	Checkered Plate,	34″	$\frac{5}{16}$	13.77	31
M52	"	34″	$\frac{3}{8}$	16.32	. .
M53	"	34″	$\frac{7}{16}$	18.87	. .
M54	"	34″	$\frac{1}{2}$	21.42	. .

SPECIAL TEES.

Section Index.	Size, in inches.	Weight per foot.	Page No. of Section.	Section Index.	Size, in inches.	Weight per foot.	Page No. of Section.
T154	$4\frac{1}{2}\times2\frac{3}{16}$	7.00	26	T156	$4\times2\frac{3}{4}$	11.00	26

RAIL.

Section Index.	Size, in inches.	Weight per foot.	Page No. of Section.
R4	$1\frac{5}{8}\times1\frac{1}{4}$	$1\frac{3}{4}$	26

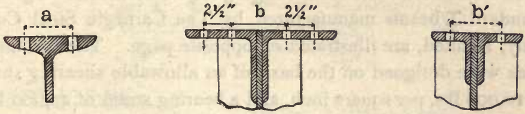
CAST SEPARATORS FOR I BEAMS.

See illustrations page 57, Figs. 9 and 10.

Separators for 20″ and 24″ beams are made of ⅝″ metal.
" " 6″ to 15″ beams are made of ½″ metal.
" " 5″ beams and under are made of ⅜″ metal.

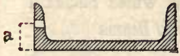
Designation of Beam. Depth. inches.	Designation of Beam. Shape Index.	Designation of Beam. Weight. lbs.	Distances. Out to out of flanges of beams. inches.	Distances. Center to center of beams. inches.	Bolts. Size. inch.	Bolts. Distance, center to center. inches.	Bolts. Length. inches.	Weights. Bolts and nuts. lbs.	Weights. Increase in weight of separator bolts for 1 inch additional spread of beams. lbs.	Weights. Separator. lbs.	Weights. Increase in weight of separator for 1 inch additional spread of beams. lbs.
SEPARATORS WITH TWO BOLTS.											
24	B 1	80	14¾	7¾	⅞	12	9½	4½	0.33	31½	5½
20	B 2	80	14¾	7¾	⅞	10	9½	4½	"	24¾	3 1/16
20	B 3	64	13¼	7	⅞	10	8½	4½	"	22	"
15	B 4	80	13⅝	7¼	¾	7	9	3½	0.25	13¼	1¾
15	B 5	60	12½	6½	¾	7	8	3¼	"	12¼	"
15	B 6	50	12¼	6½	¾	7	8	3¼	"	12¼	1 13/16
15	B 7	41	11½	6	¾	7	7½	3	"	11½	"
12	B 8	40	11½	6	¾	6½	7⅜	3	0.25	9¼	1 7/16
12	B 9	32	11¼	6	¾	6½	7⅜	3	"	9½	1½
SEPARATORS WITH ONE BOLT.											
12	B 8	40	11½	6	¾	. .	7⅜	1½	0.12	9¼	1 7/16
12	B 9	32	11¼	6	¾	. .	7⅜	1½	"	9½	1½
10	B 10	33	10½	5½	¾	. .	6⅞	1⅜	"	7	1 3/16
10	B 11	25	10¼	5½	¾	. .	6⅞	1⅜	"	7¼	1¼
9	B 13	21	9½	5	¾	. .	6¼	1⅜	"	6	1⅛
8	B 15	18	9¼	5	¾	. .	6¼	1⅜	"	5½	15/16
7	B 17	15	8¾	4¾	¾	. .	6	1¼	"	4½	13/16
6	B 19	13	7½	4	¾	. .	5¼	1¼	"	2¼	9/16
5	B 21	10	6½	3½	¾	. .	4¾	1⅛	"	1¾	7/16
4	B 23	7	5⅞	3¼	¾	. .	4½	1⅛	"	1½	⅜
3	B 77	6	5¼	3	⅝	. .	4¼	¾	0.10	1½	¼

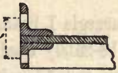
STANDARD SPACING AND DIMENSIONS OF RIVET AND BOLT HOLES THROUGH FLANGES AND CONNECTION ANGLES OF I BEAMS.



Depth in inches.	Weight per foot.	Dia. of bolt or rivet, in inches.	a in inches.	b or b′ in inches.	Depth in inches.	Weight per foot.	Dia. of bolt or rivet, in inches.	a in inches.	b or b′ in inches.
24	80	¾	4	b′=5	10	33	¾	2¾	b=4⅜
20	80	¾	4	“ 5⅛	10	25	¾	2½	“ 4 5/16
20	64	¾	3½	“ 5	9	21	¾	2½	“ 4 5/16
15	80	¾	3½	b=4¾	8	18	¾	2¼	“ 4¼
15	60	¾	3¼	“ 4 9/16	7	15	⅝	2¼	“ 4¼
15	50	¾	3	“ 4½	6	13	⅝	2	b′=4¼
15	41	¾	3	“ 4 7/16	5	10	½	1¾	“ 4¼
12	40	¾	3	“ 4⅜	4	7	½	1½	“ 4 3/16
12	32	¾	2¾	“ 4⅜	3	6	⅜	1⅜	“ 4 3/16

CHANNELS.





ANGLES.

Depth in inches.	Weight per foot.	a in inches.	b′ in inches.	Dia. of bolt or rivet, in inches.	Depth of leg, in inches.	Maximum diam. of bolt or rivet, in inches.	c in inches.	Depth of leg, in inches.	Maximum diam. of bolt or rivet, in inches.	c in inches.
15	33.0	1⅞	4⅞	¾	7	1	3½	2	⅝	1⅛
13	31.5	2	. .	¾	6	1	3½	1¾	⅝	15/16
12	20.0	1⅝	4 13/16	¾	5	1	2¾	1½	½	13/16
10	16.5	1½	4¼	¾	4½	1	2½	1⅜	½	¾
9	14.0	1⅜	4¼	¾	4	1	2¼	1¼	½	11/16
8	11.0	1¼	4¼	¾	3½	1	2	1⅛	½	⅝
7	9.5	1⅛	4 3/16	⅝	3¼	⅞	1¾	1 1/16	⅜	⅝
6	8.0	1	4 3/16	⅝	3	⅞	1¾	1	⅜	9/16
5	6.5	1	4 3/16	⅝	2¾	¾	1½	⅞	⅜	½
4	5.5	1	4 3/16	½	2½	¾	1⅜	¾	¼	7/16
3	5.0	1	4 3/16	⅜	2¼	¾	1¼	⅝	3/16	⅜

NOTE: The spaces b′ in above table correspond with spacings given on page 50 for standard connection angles.

NOTES ON STANDARD CONNECTION ANGLES FOR CARNEGIE I BEAMS.

The standard connection angles, for all sizes and weights of Standard I beams manufactured by The Carnegie Steel Company, Limited, are illustrated on opposite page. These connections were designed on the basis of an allowable shearing strain of 10,000 lbs. per square inch, and a bearing strain of 20,000 lbs. per square inch on rivets or bolts, corresponding with extreme fiber strains in the I beams of 16,000 lbs. per square inch. The number of rivets or bolts required was found to be dependent, in most instances, on their bearing values.

The connections have been proportioned with a view to covering most cases, occuring in ordinary practice, with the usual relations of depth of beam to length of span. In extreme instances, however, where beams of short relative span lengths are loaded to their full capacity, it may be found necessary to make provision for additional strength in the connections. The limiting span lengths, at and above which the standard connection angles may be used with perfect safety, are given in the following table:

Table of Minimum Spans, for Carnegie I Beams, for which Standard Connection Angles may be Safely Used, with Beams Loaded to their Full Capacity.

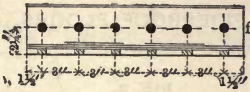
Designation of Beam.	Minimum Safe Span, in feet.	Designation of Beam.	Minimum Safe Span, in feet.	Designation of Beam.	Minimum Safe Span, in feet.
24″–80. lbs.	20.5	15″–41. lbs.	10.5	8″–18. lbs.	7.0
20″–80. "	17.0	12″–40. "	8.5	7″–15. "	5.5
" 64. "	16.0	" 32. "	7.5	6″–13. "	6.0
15″–80. "	12.5	10″–33. "	10.5	5″–10. "	4.0
" 60. "	11.5	" 25. "	9.0	4″– 7. "	3.0
" 50. "	11.0	9″–21 "	8.0	3″– 6. "	3.0

See illustrations of Standard Connection Angles for Carnegie I Beams on opposite page.

STANDARD CONNECTION ANGLES.

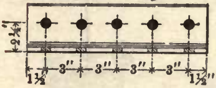
FOR I BEAMS.

4"×4"×3/8" L – 1'-6" lg.



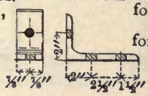
for 24" I { 100 lbs. 80 lbs.

4"×4"×3/8" L – 1'-3" lg.



for 20" I { 80 lbs. 64 "

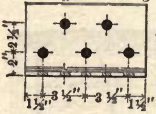
6"×3½"×3/8" L – 1¾"



for 3" I { 6 lbs.

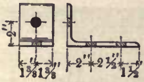
for 4" I { 7 lbs.

6"×6"×7/16" L – 0'-10" lg.



for 15" I { 80 lbs. 60 " 50 " 41 "

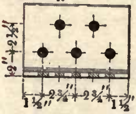
5"×3½"×3/8" L – 0'-2¾" lg.



for 5" I { 10 lbs.

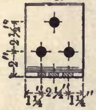
for 6" I { 13 lbs.

6"×6"×7/16" L – 0'-8½" lg.



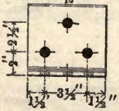
for 12" I { 40 lbs. 32 "

6"×6"×7/16" L – 0'-4¾" lg.



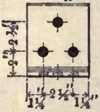
for 7" I { 15 lbs.

6"×6"×7/16" L – 0'-6½" lg.



for 10" I { 25 lbs. 33 "

6"×6"×7/16" L – 0'-5" lg.

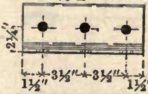


for 8" I { 18 lbs.

for 9" I { 21 lbs.

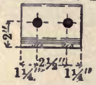
CHANNELS.

4"×4"×3/8" L – 0'-10" lg.



for 15" [– 33 lbs.

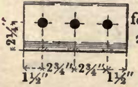
3½"×3½"×3/8" L – 0'-5" lg.



for 8" [{ 11 lbs.

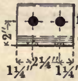
for 9" [{ 14 lbs.

4"×4"×3/8" L – 0'-8½" lg.



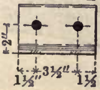
for 12" [20 lbs.

3½"×3½"×3/8" L – 0'-4¾" lg.



for 7" [9.5 lbs.

3½"×3½"×3/8" L – 0'-6½" lg.



for 10" [16.5 lbs.

Connections for 3", 4", 5" and 6" I-beams apply also to Channels.
All holes for ¾" Bolts or Rivets.

FIREPROOF FLOORS.

Fig. 1.

Fig. 2.

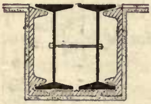


Fig. 3.

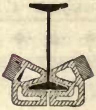


Fig. 4.

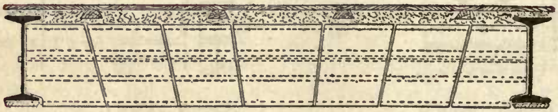


Fig. 5.

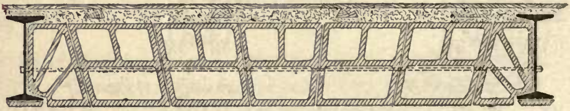


Fig. 6.

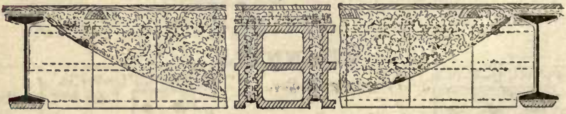
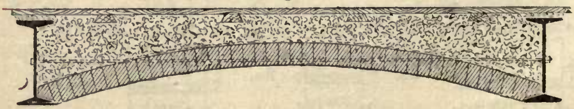


Fig. 7.



FIREPROOF FLOORS AND PARTITIONS.

Fig. 1

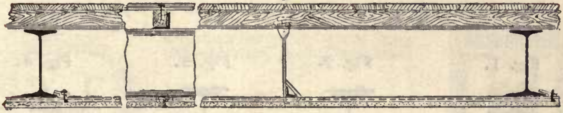


Fig. 2.

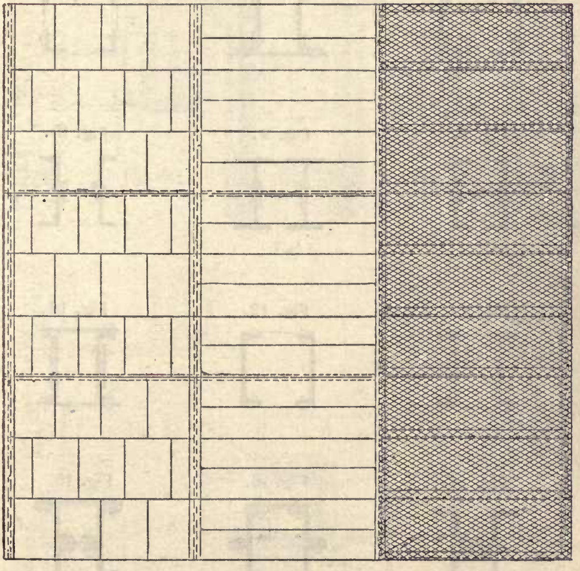


Fig. 3.

BUILT COLUMN SECTIONS.

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

Fig. 7.

Fig. 8.

Fig. 9.

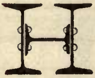


Fig. 10.

Fig. 11.

Fig. 12.

Fig. 13.

Fig. 14.

Fig. 15.

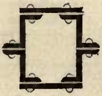


Fig. 16.

DETAILS SHOWING FIREPROOFING, AND BASES FOR Z-BAR COLUMNS.

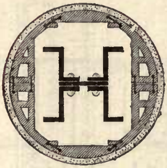


Fig. 2.

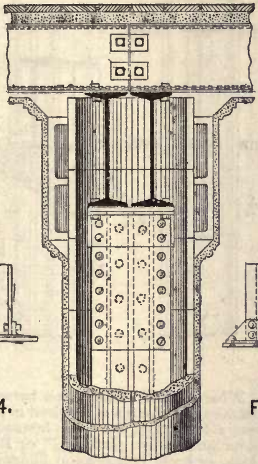


Fig. 1.

Fig. 3.

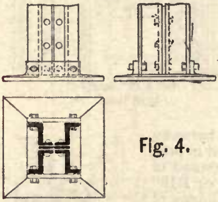


Fig. 4.

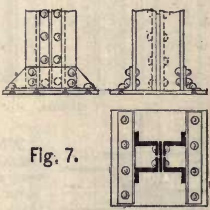


Fig. 7.

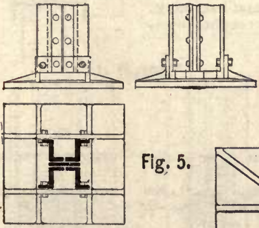


Fig. 5.

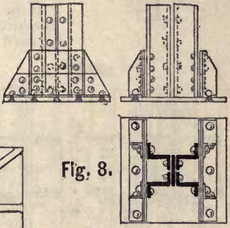


Fig. 8.

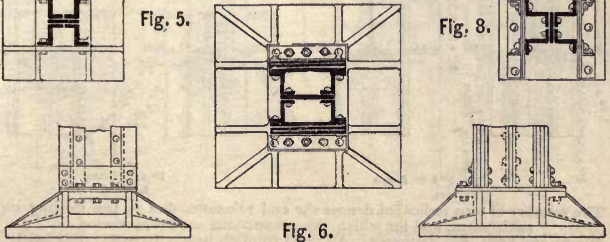
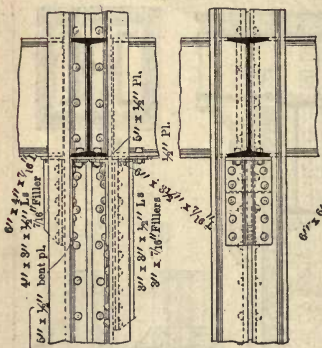


Fig. 6.

DETAILS OF STANDARD CONNECTIONS OF I-BEAMS AND Z-BAR COLUMNS.

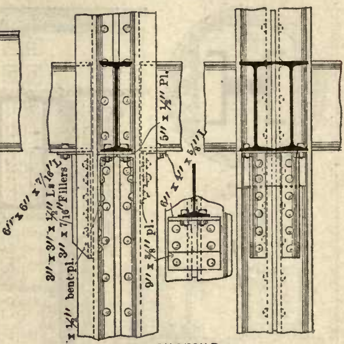
These connections to be used when columns are not spliced at seat level of girder.

Fig. 1.

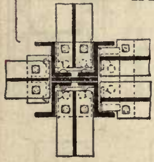


24″ & 20″ Beams
22 Tons.

Fig. 2.



15″ & 12″ Beams
13.25 Tons



Where a rigid connection between beams and columns is required to prevent side motion, use rivets instead of bolts and insert plates ⅛″ or 1-16″ thick, or both, between top flanges of beams and columns, as shown in Fig. E, opposite page.

If the space is large, cast iron may, in addition to the thin wrought plates, be used to advantage.

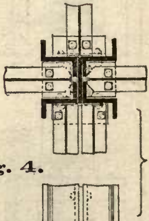
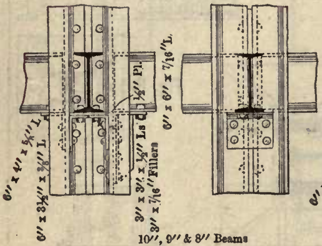
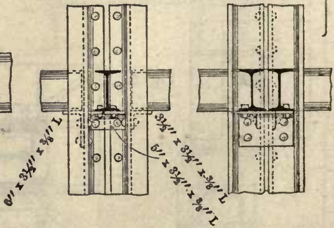


Fig. 3.



10″, 9″ & 8″ Beams
8.8 Tons.

Fig. 4.



7″ x 6″ Beams
4.4 Tons.

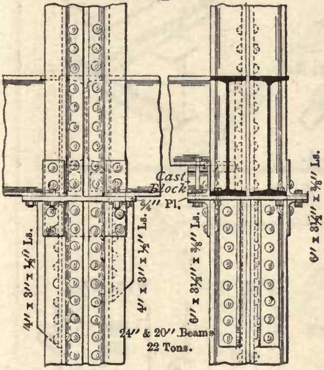
The number of tons indicated denote the end reactions due to the loading on each beam, and for which the connections are proportioned.

Rivets and bolts, ¾″ diameter. All bolts through beams have bevelled heads.

DETAILS OF STANDARD CONNECTIONS OF I-BEAMS AND Z-BAR COLUMNS.

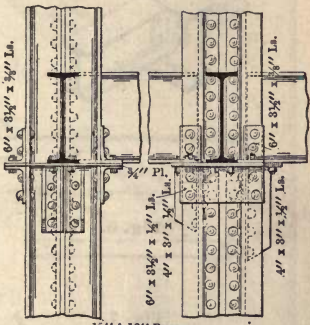
These connections to be used when columns are spliced at seat level of girder. This is the usual arrangement.

Fig. A.



24" & 20" Beams
22 Tons.

Fig. B



15" & 12" Beams
13.25 Tons.

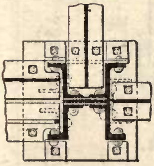
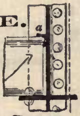


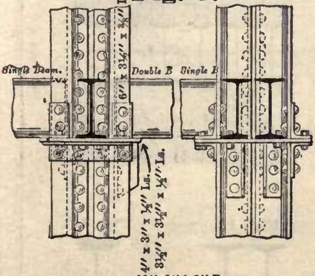
Fig. E.

Where a rigid connection between beams and columns is required to prevent side motion, use rivets instead of bolts, and insert plates ⅛" or 1-16" thick, or both, between top flanges of beams and columns, thus:



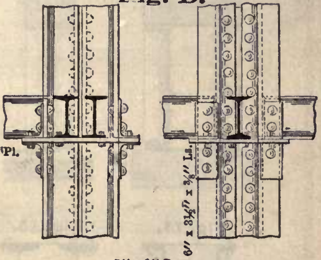
If the space is large, cast iron may, in addition to the thin wrought plates, be used to advantage, thus:

Fig. C.



10", 9" & 8" Beams
8·8 Tons.

Fig. D.



7" & 6" Beams
4.4 Tons.

The number of tons indicated denote the end reactions due to the loading on each beam, and for which the connections are proportioned.
Rivets and bolts, ¾" diameter. All bolts through beams have bevelled heads.

CONSTRUCTIONAL DETAILS.

Fig. 1.

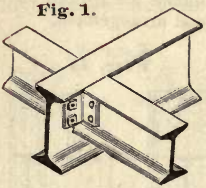


Fig. 2.

Fig. 3.

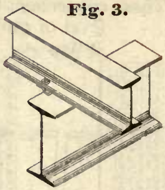


Fig. 4.

Fig. 5.

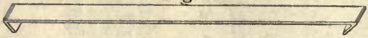


Fig. 6.

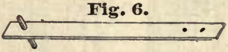


Fig. 7.

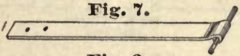


Fig. 8.

Fig. 9.

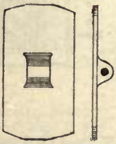


Fig. 10.

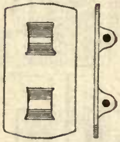


Fig. 11.

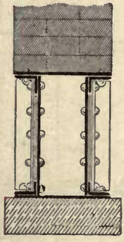


Fig. 12.

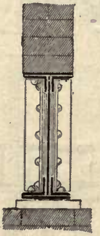


Fig. 13.

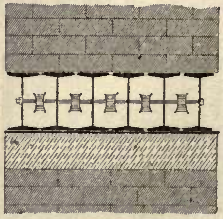


Fig. 14.

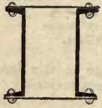


Fig. 15.

Fig. 16.

Fig. 17.

METHOD OF INCREASING SECTIONAL AREAS.

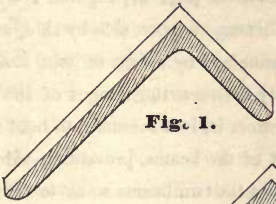


Fig. 1.

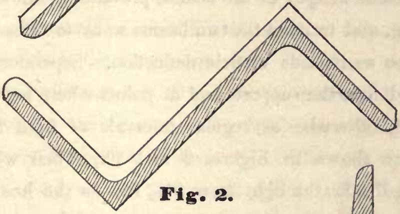


Fig. 2.

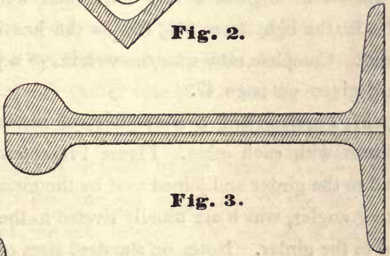


Fig. 3.

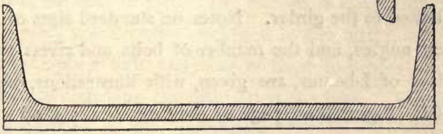


Fig. 4.

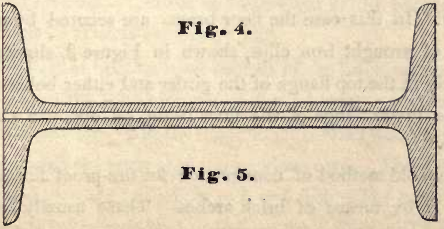


Fig. 5.

GENERAL NOTES ON FLOORS.

Examples of floor joists and their connections, of common occurrence, are shown on page 57, Figures 1 and 3. Girders consisting of two I-beams, or more, side by side, as in Figures 16 and 13, should be connected by means of bolts and cast-iron separators, fitting closely between the flanges of the beams. The office of these separators is, in a measure, to hold in position the compression flanges of the beams, preventing side deflection or buckling, and to unite the two beams so as to cause them to act in unison as regards verticle deflection. Separators should be provided near the supports and at points where heavy loads are imposed, otherwise at regular intervals of from 5 to 6 feet; these are shown in Figures 9 and 10. Their weights range from 1½ lbs. for the light 3″, to 31½ lbs. for the heaviest section of 24″ beams. Complete tables for the weights of separators for I-beams are given on page 47.

On page 57, Figures 1 and 3 show different methods of connecting beams with each other. Figure 1 represents the floor beam coped to the girder and joined to it by the means of a pair of connecting angles, which are usually riveted to the floor beam and bolted to the girder. Notes on standard sizes of these connecting angles, and the number of bolts and rivets required for all sizes of I-beams, are given, with illustrations, on pages 49 and 50. Figure 3 on page 57 indicates the method of connecting the floor beams with the girders when they rest on top of the latter. In this case the floor beams are secured by means of a pair of wrought iron clips, shown in Figure 2, shaped so as to closely fit the top flange of the girder and either bolted or riveted to the lower flange of the floor beam, on opposite sides of the same.

The old method of construction for fire-proof floors in buildings is by means of brick arches. These usually consist of a

single 4″ course of brick, with a rise at the center of 3 or 4 inches and resting on the lower flanges of the I-Beams, against brick skewbacks. This method of construction is illustrated on page 51. Figure 7. In case the floor is designed for very heavy loads several courses of brick should be used. The floor beams should be placed about 5 or 6 feet, center to center. A convenient device for centering the arches consists of wooden frames, called centers, suspended by iron hooks from the lower flanges of the beams, and detachable on one side so that they may be shifted at pleasure as the work progresses. The space above the arches is filled with concrete, in which are embedded wooden strips for securing the flooring. To finish the ceiling below, plaster is generally applied on the bottom of the arches, directly to the brick work. The horizontal thrust of the arches is provided for by the use of tie rods, from ⅝″ to ⅞″ diameter, spaced along the center line of the beams, or a little below, at regular intervals of from 5 to 7 feet. The thrust of these arches per lineal foot can be found by the formula $T = \frac{1.5WL^2}{R}$ in which W is equal to the load per square foot, R the rise of the arch in inches, and L the span in feet. The tie rods in the arch abutting against the wall are securely anchored to the wall; an angle, channel or simply a wall plate can be used to support the arch and to properly distribute the load upon the wall. The weight of a fire-proof floor of this description, that is, 4″ brick arches, concrete and flooring, exclusive of the weight of the beams, will average about 70 pounds per square foot.

Corrugated sheet may be used instead of the brick arches. It is placed against the lower flanges of the I-beams, and thus securely held in position, while the space above is filled with grouting. Tie rods are used the same as in the previous case. The distance between beams should be limited to 5 or 6 feet. The corrugated sheet is usually left exposed below to form the ceiling, and it is thus

open to the objection that the moisture in the atmosphere may condense upon the surface of the sheet in sufficient quantities to drop into the room below. Ceilings of this kind should therefore be restricted in their use, or the sheets properly protected from contact of the air

Two modern types of fire-proof floor constructions, and which have grown in favor so rapidly as to be used now almost to the exclusion of all others, are illustrated on page 51, Figures 4 and 5. The arches in this case are formed of hollow blocks, consisting of burnt fire-clay or similar refractory material. These are furnished by the manufacturers in a great variety of patterns and of a strength to meet the desired requirements.

In regard to their composition, there may be said to exist two distinctive varieties.

In the first, known as hollow pottery, the material consists of burnt fire-clay, and differs from the second variety, called "porous earthenware," in being thinner, harder, and more compact.

In the second variety the clay, before it is burnt, is mixed in considerable proportions with sawdust and finely-cut straw, which, being consumed during the process of burning, leaves the material in a finely honeycombed state.

Figures 4 and 5, on page 51, show two methods of construction of hollow pottery and porous earthenware arches. The method illustrated by Figure 4 is the later and better.

From tests recently made it appears that this latter construction gives the best results in regard to strength. This is evidently due to the fact that the full section of the material is placed in its most advantageous position to take the direct pressure coming thereon.

When used in floor construction both varieties of arches are backed to the depth of several inches with concrete, in which are embedded wooden strips to which the floor planking is

secured. The joints are all made radial, and the blocks should be thoroughly cemented together. They are made to project about 1 inch below the bottom flange of the I-beams, which are further protected by the insertion of a thin strip of tile. The weight and cost of both hollow pottery and porous earthenware are about the same, and, through their superior lightness, possess an important advantage over the brick arch. The saving in weight amounts to from 40 to 50 per cent., thus warranting more economical proportions for the steel framing, while in other respects the cost of this construction is about the same. The weight of these arches per square foot of floor, without plastering, concrete or flooring, is about as follows:

12″	arches, used for warehouses,	45 lbs.
10″	" " " theatres,	36 lbs.
8″	" " " office buildings,	30 lbs.
6″	" " " light purposes,	22 lbs.

For long spans or unusually heavy loads special arches should be constructed. A combination arch, to satisfy this purpose is shown on page 51, Figure 6. It consists of hollow fire-proof blocks of the ordinary dimensions, as used for partitions, from 4″ to 12″ wide and about 12″ in depth, set end to end and supported by steel or iron tension straps fastened by good and substantial means to the webs or upper flanges of the beams. These straps must be of sufficient strength and placed between the successive rows of the fire-proof blocks. The space over the straps and between the fire-proof blocks is filled up with Portland cement, thus uniting the blocks and producing a solid floor. The fire-proofing, therefore, no longer serves the function of an arch, but merely takes the compression caused by the strap, whose tendency is to pull the floor beams together.

The straps should be at least 1½″ wide and not less than ¼″ in thickness. Tests made by The Carnegie Steel Company, Limited,

with this combination construction have given very satisfactory results.

The following are the usual assumptions made in good practice for superimposed loads:

Floors of dwellings and offices,	70 lbs.	per sq. ft.
" " churches, theatres and ball rooms,	125 lbs	" " "
" " warehouses,	200 to 250 lbs.	" " "
" for heavy machinery,	250 to 400 lbs.	" " "

It has been shown by a careful investigation that the weight of a crowd of people, densely packed, will not exceed 80 lbs. per square foot.

The cost of fire-proof floor construction has been further greatly reduced by the substitution of steel for iron in the manufacture of I-beams and channels. The former material recommends itself, not only for its superior strength, but also by its use the rolling of much lighter sections than in iron has been rendered practicable. These advantages are now universally conceded, and in view of this fact, The Carnegie Steel Company, Limited, have discarded the use of iron, and the manufacture of structural shapes consists entirely of steel.

Where girders extend below bottom of floor beams, they are made fire-proof by surrounding them with hollow earthenware blocks especially made to fit the bottom of the beams, as shown on page 51, Figures 1, 2 and 3.

An example of fire-proof tile construction, as applied to ceilings and roofs, is given on page 52, Figure 2. For ceilings the Tees are suspended from the lower flanges of the I-beams at intervals of 12″ or 15′, and support a layer of very thin tile, weighing about 5 pounds per square foot, to which the plastering is applied. For roofs somewhat heavier Tees are used, resting on the top flanges of the I-beams and spaced about 18″ apart. The tiling, weighing about 10 lbs. per square foot, may be covered with

concrete, then with a layer of felt and gravel, or, in the case of slate roofs, the slate may be nailed directly to the tiling.

A semi-fire-proof construction is shown on page 52, Figure 1, and consists of angles resting on the top of the floor beams, and supporting wooden strips. The finished floor can be directly nailed on these latter, which are spaced from 12 to 16 inches apart. The ceiling is composed of wire lathing, which is fastened to Tees suspended from the floor beams and spaced about 16″ apart. The plastering is directly attached to the wire lathing, and thus a level ceiling is obtained.

Wire lathing can also be used to good advantage in fire-proofing columns and girders, and has shown itself to be of great utility in many instances where hollow pottery could not be used.

On page 52, Figure 3, is given an elevation and section of three methods used for the construction of fire-proof partitions. One consists of the ordinary fire-proof square blocks, set with broken joints and held at intervals with light I-beams, which take the place of wood studding.

In the second me.hod, the space between the I-beams is filled with a new material called plaster boards. The third method consists of wire lathing attached to the flanges of the I-beams and stiffened at intervals of 2 feet with angles. In all these methods plastering is applied directly to the surfaces in the usual manner.

GIRDERS IN BUILDINGS.

In the design of a building, cases may occur where a single I-beam girder will not answer. It may be found desirable to increase the lengths of the spans so as to reduce the number of supporting columns to a minimum, or perhaps heavy concentrated loads, such as vaults, brick walls, etc., will render single I-beam girders inadequate. On page 57, Figs. 11 to 17, inclusive, are shown various forms of girders that may be used in such cases Where the ends of the girders rest upon the wall, steel bearing plates (Figs. 12 and 13), should be used to distribute the pressure over a greater surface, and thereby prevent the crushing of the material in the wall directly under the girder. In some cases a tough, large stone will answer without the plates (Fig. 11), but where the pressure is heavy, both plates and stone should be used (Fig. 13).

The allowed pressure per square foot for brick work should not exceed six tons, and for stone, twelve to twenty tons, according to its character.

For spanning openings in brick walls, girders composed of two or more I-beams, connected by bolts and separators (Figs. 13 and 16, page 57), are most commonly used.

The probable line of rupture, where the bricks have been laid regularly, if the girder should fail, will be found to be inside of the sides of an isosceles triangle whose base is the span and whose height is $\frac{1}{3}$ of the span. In order to be entirely on the safe side, the weight of wall between vertical lines directly over the girder for a height equal to that of the triangle is frequently adopted as the load to be carried. It should be noted however that for green walls or walls having openings, this rule does not apply.

Placing the weight of brick work at 112 lbs. per cubic foot, the weights per superficial foot for different walls are as follows:

For 9″ wall	. . . .	84 lbs.
" 13 "	. . . .	121 "
" 18 "	. . . .	168 "
" 22 "	. . . .	205 "
" 26 "	. . . .	243 "

EXPLANATION OF TABLES ON CARNEGIE SECTIONS.

PAGES 70 TO 90, INCLUSIVE.

These tables have been calculated for the lightest weights to which each shape or pattern can be rolled. Heavier weights can be rolled in the same grooves by separating the rolls, but they are not kept in stock, and can only be obtained by special rolling.

The tables on pages 71 to 73 for I-beams, give the loads which a beam will carry safely (distributed uniformly over its length) for the distances between supports indicated. These loads include the weight of the beam, which must be deducted in order to arrive at the *net load* which the beam will carry. On pages 74 to 82, will also be found the safe loads for other sections.

For beams of heavier sections than those calculated in the tables, a separate column of corrections is given for each size, stating the proper increase of safe load for every additional pound in the weight per foot of beam. The values given are based on a maximum fiber strain of 16,000 lbs. per square inch for I-beams and channels, while for other shapes, 12,000 lbs. has been used.

It has been assumed in these tables that proper provision is made for preventing the compression flanges of the beams from deflecting sideways. They should be held in position at distances not exceeding twenty times the width of the flange, otherwise the strain allowed should be reduced as per table, page 69.

In some instances *deflection*, rather than *absolute strength*, may become the governing consideration in determining the size of beam to be used. For beams carrying plastered ceilings, for example, it has been found by practical tests that, if the deflection exceeds $\frac{1}{360}$th of the distance between supports, or $\frac{1}{30}$th of an inch per foot of this distance, there is danger of the ceiling cracking. This limit is indicated in the following tables by cross lines, beyond which the beams should not be used, if

intended to carry plastered ceilings, unless the allowable loads given in the tables are reduced. There is an element of safety not taken into account in the tables, viz., the fact that the dead load of the floor is carried by the beams before the plaster is applied; consequently, only the deflection due to the live load is liable to cause damage to the plaster. The following method can be used to obtain the reduced loads:

Multiply the load given immediately above the cross line by the square of the corresponding span, and divide by the square of the required span; the result will be the required load. *See example III, page* 69.

A table of deflections of Carnegie sections is given on page 70. It may generally be assumed, both for rolled and built beams, that the above limit is not exceeded so long as the depth of the beam is not less than $\frac{1}{20}$th of the distance between supports (⅝ inch per foot).

Inasmuch as the carrying capacity of beams increases largely with their depth, and it is therefore economical to use the greatest depth of beam consistent with the other conditions to which it is necessary to conform, (as clear height, etc.), the above cases of extreme deflection will rarely be met with in practice.

As the deflection of beams is not very uniform in either iron or steel, the question of the relative deflection of iron and steel beams can be decided only from the average results of a large number of tests. Such experiments as have been made, though insufficient in number to be conclusive, indicate that a steel beam will deflect slightly less than an iron beam of the same section, under the same load, in about the inverse ratio of the moduli of elasticity for these materials as generally assumed, or say as 14 to 15.

The tables on pages 83 to 90, inclusive, for I-beams give the proper spacing, center to center of beams, for loads varying from 100 to 175 lbs. per square foot, and for spans ranging in length from 5 to 30 feet. The spacing of beams is inversely proportionate to the loads; therefore, for a load not given in the table, as for instance, 200 lbs. per square foot, divide the spaces given for 100 lbs. per square foot by 2, etc.

EXAMPLES OF APPLICATION OF TABLES.

I. What will be the most economical arrangement of floor beams and girders for carrying a load of 150 lbs., including weight of floor, assuming the floor to be supported by brick arches resting between the beams and carrying a plastered ceiling below?

Answer: The spacing of floor beams for brick arches, as stated above, should not exceed 6 feet. Referring to pages 87 and 88, we find the *deepest* I-beam corresponding to this space (above horizontal cross lines) to be a 9″ I, 21.0 lbs., with a length of span of 15 feet. The girders to which the floor beams are framed should, therefore, be spaced 15 feet apart, and from the table we find that either a 20″ I, 64 lbs., 23 feet long, or a 15″ I, 50 lbs., 18 feet long, will answer. By using the former, the number of supporting columns will be reduced, but the weight of the girders increased. The relative cost must be determined by the circumstances of the case *i. e.*, length of columns, etc. The headroom required may render it necessary to use a double girder of shallower beams, say 2—10″ I-beams, 25 lbs, 15 feet long.

II. What size and weight of beam 19′ 6″ long in clear between walls, and therefore, 20′ 0″ long between centers of supports, will be required to carry safely a uniformly distributed load of 16 tons, the weight of the beam included?

Answer: From the table for safe loads of I-beams, a 15″ I, 41.0 lbs., will carry safely, for a span of 20 feet, 15.08 tons, or 0.92 tons less than required in this case. From the next column we find that for every pound increase in weight of beam, we may add 0.20 tons to the load. Hence, for 0.92 tons, we must increase

the weight per foot of beam by $0.92 \div 0.20 = 4.6$ lbs., *i. e.*, the beam required should weigh $41.0 + 4.6 = 45.6$ lbs. per foot.

III. What load uniformly distributed, including its own weight, will a 15″ I-beam, weighing 50.0 lbs. per foot, carry for a span of 30 feet, without deflecting sufficiently to endanger a plastered ceiling?

Answer: From the table for safe loads of I-beams we find, at the limit indicated for plastered ceilings, that a 15″ 50 lb. beam will carry safely a uniform load of 15.06 tons over a span of 25 feet. In order not to give rise to undue deflection, the safe load for a 30 foot span, according to the rule given on page 67 will be $\frac{15.06 \times 25^2}{30^2} = 10.46$ tons.

BEAMS WITHOUT LATERAL SUPPORT.

Length of Beam.	Proportion of Tabular Load Forming Greatest Safe Load.
20 times flange width.	Whole tabular load.
30 " " "	$\frac{9}{10}$ " "
40 " " "	$\frac{8}{10}$ " "
50 " " "	$\frac{7}{10}$ " "
60 " " "	$\frac{6}{10}$ " "
70 " " "	$\frac{5}{10}$ " "

DEFLECTION COEFFICIENTS FOR CARNEGIE SHAPES, GIVEN IN 64ths OF AN INCH.

Coefficient Index.	DISTANCE BETWEEN SUPPORTS, IN FEET.								
	6	8	10	12	14	16	18	20	22
C. S.	38.1	67.8	105.9	152.5	207.6	271.2	343.2	423.7	512.7
C′. S.	29.8	53.0	82.8	119.2	162.2	211.8	268.1	331.0	400.5
C. I.	30.7	54.6	85.3	122.9	167.3	218.4	276.5	341.3	413.0
C′. I.	25.6	45.5	71.1	102.4	139.4	182.0	230.4	284.4	344.2

Coefficient Index.	DISTANCE BETWEEN SUPPORTS, IN FEET.								
	24	26	28	30	32	34	36	38	40
C. S.	610.2	716.1	830.5	953.4	1085.0	1225.0	1373.0	1530.	1695.
C′. S.	476.6	559.4	648.8	744.8	847.4	956.6	1073.0	1195.	1324.
C. I.	491.5	576.8	669.0	768.0	873.8	986.4	1106.0	1232.	1365.
C′. I.	409.6	480.7	557.5	640.0	728.2	822.0	921.6	1027.	1138.

Figures given opposite C. S. and C′. S. are the deflection coefficients for steel shapes, subject to transverse strain for varying spans, under their maximum uniformly distributed safe loads, derived from a fiber strain of 16000 and 12500 respectively; the modulus of elasticity being taken at 29,000,000. Figures given opposite C. I. and C′. I. are for iron beams, under their uniformly distributed safe loads, derived from a fiber strain of 12000 and 10000 respectively, the modulus of elasticity being taken at 27,000,000. To find the deflection of any symmetrical shape used as a beam under its corresponding safe load, divide the coefficients given in the above tables by the depth of the beam. This applies to such shapes as I-Beams, channels, Z-bars, etc. For those beams having unsymmetrical axes, such as tees, angles, etc., divide by twice the greatest distance of the neutral axis from the outside fibre.

EXAMPLE:—Required the deflection of a 12″ I-Beam, 32 lbs., 20 ft. span under its maximum uniformly distributed safe load of 9.88 tons, as given on page 71. The above tables give 423.7 as the deflection coefficient; dividing this by 12, gives 35.3 as the required deflection in 64ths of an inch.

For deflections due to different systems of loading, see page 96.

SAFE LOADS, UNIFORMLY DISTRIBUTED, FOR CARNEGIE I-BEAMS.

IN TONS OF 2,000 LBS.

Distance between supports in feet.	24″ I.	Add for every lb. increase in weight.	20″ I.		Add for every lb. increase in weight.	15″ I.				Add for every lb. increase in weight.	12″ I.		Add for every lb. increase in weight.
	80 lbs.		80 lbs.	64 lbs.		80 lbs.	60 lbs.	50 lbs.	41 lbs.		40 lbs.	32 lbs.	
12	76.27	0.53	64.40	50.93	0.44	46.58	38.18	31.39	25.13	0.33	20.84	16 47	0.26
13	70.41	0.49	59.45	47.01	0.40	42.99	35.24	28 97	23.20	0.30	19.24	15.20	0.24
14	65.38	0.46	55.20	43.66	0.37	39.93	32.72	26.90	21.54	0.28	17.86	14.12	0.22
15	61.02	0.43	51.52	40.75	0.35	37.26	30.54	25.11	20.10	0.26	16.67	13.18	0.21
16	57.20	0.40	48.30	38.20	0.33	34.93	28.63	23.54	18 85	0.25	15.63	12.35	0.20
17	53.84	0.38	45.46	35.95	0.31	32.88	26.95	22.16	17.74	0.23	14.71	11.63	0.18
18	50.85	0.36	42.93	33.96	0.29	31.05	25.45	20.93	16.75	0.22	13.90	10.98	0 17
19	48.17	0.34	40.67	32.17	0.28	29.41	24.11	19.82	15.87	0.21	13.17	10.40	0.17
20	45.76	0.32	38.64	30.56	0.26	27.94	22.91	18.83	15.08	0.20	12.51	9.88	0.16
21	43.58	0.30	36.80	29.10	0.25	26.61	21.81	17.93	14.36	0.19	11.91	9.41	0.15
22	41.60	0 29	35.13	27.78	0.24	25.40	20.82	17.12	13.71	0.18	11.37	8.98	0.14
23	39.79	0.28	33.60	26.58	0.23	24.30	19.92	16.37	13.11	0.17	10.87	8.59	0.14
24	38.14	0.27	32.20	25.47	0.22	23.29	19.09	15.69	12.57	0.16	10.42	8.23	0.13
25	36.61	0.26	30.91	24.45	0.21	22.35	18.33	15.06	12.06	0.16	10.01	7.90	0.13
26	35.20	0.25	29.72	23.51	0.20	21.50	17.62	14.48	11.60	0.15	9.62	7.60	0.12
27	33.90	0.24	28.62	22.64	0.19	20.70	16.97	13.95	11.17	0.15	9.26	7.32	0.12
28	32.69	0.23	27.60	21.83	0.19	19.96	16 36	13.45	10.77	0.14	8.93	7.06	0.11
29	31.56	0.22	26.65	21.08	0.18	19.27	15.80	12 98	10.40	0.14	8.62	6.82	0.11
30	30.51	0.21	25.76	20.37	0.17	18.63	15.27	12.55	10.05	0.13	8.34	6.59	0.10
31	29.52	0.21	24.93	19.72	0.17	18.03	14.78	12.15	9.73	0.13	8.07	6.37	0.10
32	28.60	0.20	24.15	19.10	0.16	17.46	14.32	11.77	9.43	0.13	7.81	6.18	0.10
33	27.73	0.19	23.42	18.52	0.16	16.94	13.88	11.41	9.14	0.12	7.58	5.99	0 10
34	26.92	0 19	22.73	17.97	0.15	16.44	13.48	11.08	8.87	0.11	7.36	5 81	0.09
35	26.15	0.18	22.08	17.46	0.15	15.97	13 09	10.76	8.62	0.11	7.14	5.65	0.09
36	25.42	0.18	21.47	16.98	0.15	15.52	13.73	10.46	8.38	0.11	6.95	5.49	0.09

Safe loads given include weight of beam. Maximum fiber strain, 16,000 lbs. per square inch.

SAFE LOADS, UNIFORMLY DISTRIBUTED, FOR CARNEGIE I BEAMS.

IN TONS OF 2,000 LBS.

Distance between supports in feet.	10″ I.		Add for every lb. increase in weight.	9″ I.	Add for every lb. increase in weight.	Distance between supports in feet.	8″ I.	Add for every lb. increase in weight.	7″ I.	Add for every lb. increase in weight.
	33 lbs.	25 lbs.		21 lbs.			18 lbs.		15 lbs.	
12	14.33	10.88	0.22	8.33	0.20	5	15.40	0.42	11.58	0.37
13	13.23	10.05	0.20	7.69	0.18	6	12.83	0.35	9.65	0.31
14	12.29	9.33	0.19	7.14	0.17	7	11.00	0.30	8.27	0.26
15	11.47	8.71	0.17	6.66	0.16	8	9.63	0.26	7.24	0.23
16	10.75	8.16	0.16	6.25	0.15	9	8.56	0.23	6.43	0.20
17	10.12	7.68	0.15	5.88	0.14	10	7.70	0.21	5.79	0.18
18	9.56	7.26	0.15	5.55	0.13	11	7.00	0.19	5.27	0.17
19	9.05	6.87	0.14	5.26	0.12	12	6.42	0.17	4.83	0.15
20	8.60	6.54	0.13	5.00	0.12	13	5.92	0.16	4.45	0.14
21	8.19	6.22	0.12	4.76	0.11	14	5.50	0.15	4.14	0.13
22	7.82	5.94	0.12	4.54	0.11	15	5.13	0.14	3.86	0.12
23	7.48	5.69	0.11	4.35	0.10	16	4.81	0.13	3.63	0.11
24	7.17	5.45	0.11	4.17	0.10	17	4.53	0.12	3.41	0.11
25	6.88	5.23	0.10	4.00	0.09	18	4.28	0.12	3.22	0.10
26	6.62	5.02	0.10	3.84	0.09	19	4.05	0.11	3.04	0.10
27	6.37	4.84	0.10	3.70	0.09	20	3.85	0.10	2.90	0.09
28	6.14	4.67	0.09	3.57	0.08	21	3.67	0.10	2.76	0.09
29	5.93	4.51	0.09	3.45	0.08	. .	. .	. .	. .	. .
30	5.73	4.36	0.09	3.33	0.08	. .	. .		. .	. .

Safe loads given, include weight of beam. Maximum fiber strain, 16,000 lbs. per square inch.

SAFE LOADS, UNIFORMLY DISTRIBUTED, FOR CARNEGIE I BEAMS.

IN TONS OF 2,000 LBS.

Distance between supports in feet.	6″ I. 13 lbs.	Add for every lb. increase in weight.	5″ I. 10 lbs.	Add for every lb. increase in weight.	4″ I. 7 lbs.	Add for every lb. increase in weight.	3″ I. 6 lbs.	Add for every lb. increase in weight.
5	8.35	0.31	5.29	0.26	3.04	0.21	1.86	0.16
6	6.96	0.26	4.41	0.22	2.54	0.17	1.55	0.13
7	5.96	0.22	3.78	0.19	2.17	0.15	1.33	0.11
8	5.22	0.20	3.31	0.16	1.90	0.13	1.16	0.10
9	4.64	0.17	2.94	0.15	1.68	0.12	1.03	0.09
10	4.18	0.16	2.65	0.13	1.52	0.10	0.93	0.08
11	3.80	0.14	2.40	0.12	1.38	0.10	0.84	0.07
12	3.48	0.13	2.20	0.11	1.27	0.09	0.77	0.06
13	3.21	0.12	2.03	0.10	1.17	0.08	0.71	0.06
14	2.98	0.11	1.89	0.09	1.09	0.07	0.66	0.05
15	2.78	0.10	1.76	0.09	1.02	0.07	0.62	0.05
16	2.61	0.10	1.65	0.08	0.95	0.07	0.58	0.05
17	2.46	0.09	1.56	0.08	0.89	0.06	0.55	0.04
18	2.32	0.09	1.47	0.07	0.84	0.06	0.52	0.04
19	2.20	0.08	1.39	0.07	0.80	0.06	0.49	0.04
20	2.09	0.08	1.32	0.07	0.77	0.05	0.46	0.04
21	1 99	0.07	1.26	0.06	0.73	0.05	0.44	0.03

Safe loads given, include weight of beam. Maximum fiber strain, 16,000 lbs. per square inch.

SAFE LOADS, IN TONS OF 2,000 LBS., UNIFORMLY DISTRIBUTED, FOR CARNEGIE DECK BEAMS AND BULB ANGLES.

Depth of Section, ins.	Weight per foot.	Maximum Fiber Strain, 12,000 lbs., per square inch.									
		DECK BEAMS—DISTANCE BETWEEN SUPPORTS, IN FEET.									
		5	6	7	8	9	10	12	14	16	18
10	35.70	20.52	17.10	14.66	12.82	11.40	10.26	8.55	7.33	6.41	5.70
10	27.23	16.93	14.11	12.09	10.58	9.41	8.46	7.05	6.05	5.29	4.70
9	30.00	15.64	13.03	11.17	9.77	8.69	7.82	6.52	5.59	4.89	4.34
9	26.00	14.18	11.82	10.13	8.86	7.88	7.09	5.91	5.06	4.43	3.94
8	24.48	11.26	9.38	8.04	7.04	6.26	5.63	4.69	4.02	3.52	3.13
8	20.15	9.74	8.12	6.96	6.09	5.41	4.87	4.06	3.48	3.04	2.71
7	23.46	9.34	7.78	6.67	5.84	5.19	4.67	3.69	3.34	2.92	2.59
7	18.11	7.73	6.44	5.52	4.83	4.29	3.86	3.22	2.76	2.42	2.15
6	18.36	6.58	5.48	4.70	4.11	3.66	3.29	2.74	2.35	2.06	1.83
6	15.30	5.80	4.83	4.14	3.62	3.22	2.90	2.42	2.07	1.81	1.61
		Maximum Fiber Strain, 10,000 lbs., per square inch.									
10	35.70	17.10	14.25	12.21	10.69	9.50	8.55	7.12	6.11	5.34	4.75
10	27.23	14.11	11.76	10.08	8.82	7.84	7.06	5.88	5.04	4.41	3.92
9	30.00	13.03	10.86	9.30	8.14	7.24	6.51	5.43	4.65	4.07	3.62
9	26.00	11.82	9.85	8.44	7.39	6.57	5.91	4.92	4.22	3.70	3.28
8	24.48	9.38	7.82	6.70	5.86	5.21	4.69	3.91	3.35	2.93	2.61
8	20.15	8.11	6.76	5.79	5.07	4.51	4.05	3.38	2.90	2.53	2.25
7	23.46	7.79	6.49	5.56	4.87	4.33	3.89	3.25	2.78	2.43	2.16
7	18.11	6.44	5.37	4.60	4.02	3.58	3.22	2.68	2.30	2.01	1.79
6	18.36	5.48	4.57	3.91	3.42	3.04	2.74	2.28	1.96	1.71	1.52
6	15.30	4.84	4.03	3.46	3.02	2.69	2.42	2.02	1.73	1.51	1.34
		BULB ANGLES—Maximum Fiber Strain, 12,000 lbs., per square inch.									
10	26.50	15.88	13.23	11.34	9.93	8.82	7.94	6.62	5.67	4.96	4.41
9	21.80	11.57	9.64	8.26	7.23	6.43	5.78	4.82	4.13	3.62	3.21
8	19.23	9.36	7.80	6.69	5.85	5.20	4.68	3.90	3.34	2.92	2.60
7	18.25	7.67	6.39	5.48	4.79	4.26	3.83	3.20	2.74	2.40	2.13
6	17.20	6.04	5.03	4.31	3.77	3.36	3.02	2.52	2.16	1.89	1.68
6	13.75	5.28	4.40	3.77	3.30	2.93	2.64	2.20	1.89	1.65	1.47
6	12.30	4.53	3.77	3.24	2.83	2.52	2.26	1.89	1.62	1.42	1.26
5	10.00	3.25	2.71	2.32	2.03	1.81	1.62	1.35	1.16	1.02	0.90
		BULB ANGLES—Maximum Fiber Strain, 10,000 lbs., per square inch.									
10	26.50	13.23	11.02	9.45	8.27	7.35	6.61	5.51	4.72	4.13	3.68
9	21.80	9.64	8.03	6.88	6.02	5.36	4.82	4.02	3.44	3.01	2.68
8	19.23	7.80	6.50	5.57	4.87	4.33	3.90	3.25	2.79	2.44	2.17
7	18.25	6.39	5.32	4.56	3.99	3.55	3.19	2.66	2.28	2.00	1.77
6	17.20	5.03	4.19	3.59	3.14	2.79	2.51	2.10	1.80	1.57	1.40
6	13.75	4.40	3.67	3.14	2.75	2.44	2.20	1.83	1.57	1.37	1.22
6	12.30	3.77	3.14	2.69	2.36	2.09	1.88	1.57	1.35	1.18	1.05
5	10.00	2.71	2.26	1.94	1.69	1.51	1.35	1.13	0.97	0.85	0.75

SAFE LOADS, UNIFORMLY DISTRIBUTED, FOR CARNEGIE CHANNELS.

IN TONS OF 2,000 LBS.

Distance between supports in feet.	15″ [. 33.0 lbs.	Add for every lb. increase in weight.	13″ [. 31.5 lbs.	Add for every lb. increase in weight.	12″ [. 20.0 lbs.	Add for every lb. increase in weight.	10″ [. 16.5 lbs.	Add for every lb. increase in weight.	9″ [. 14.0 lbs.	Add for every lb. increase in weight.
10	21.76	0.40	19.49	0.35	11.25	0.31	7.70	0.26	5.86	0.24
11	19.78	0.36	17.72	0.31	10.23	0.28	7.00	0.24	5.33	0.22
12	18.13	0.33	16.24	0.29	9.38	0.26	6.41	0.22	4.88	0.20
13	16.74	0.30	14.99	0.27	8.65	0.24	5.92	0.20	4.51	0.18
14	15.54	0.28	13.92	0.25	8.04	0.22	5.50	0.19	4.19	0.17
15	14.51	0.26	12.99	0.23	7.50	0.21	5.13	0.17	3.91	0.16
16	13.60	0.25	12.18	0.22	7.03	0.20	4.81	0.16	3.66	0.15
17	12.80	0 23	11.47	0.20	6.62	0.18	4.53	0.15	3.45	0.14
18	12.09	0.22	10.83	0.19	6.25	0.17	4.28	0.15	3.26	0.13
19	11.45	0.21	10.26	0.18	5.92	0.17	4.05	0.14	3.08	0.12
20	10.88	0.20	9.75	0.17	5.63	0.16	3.85	0.13	2.93	0.12
21	10.36	0.19	9.28	0.16	5.36	0.15	3.66	0.12	2.79	0.11
22	9.89	0.18	8.86	0.16	5.11	0.14	3.50	0.12	2.66	0.11
23	9.46	0.17	8.47	0.15	4.89	0.14	3.35	0.11	2.55	0.10
24	9.07	0.16	8.12	0.14	4.69	0.13	3.21	0.11	2.44	0.10
25	8.70	0.16	7.80	0.14	4.50	0.13	3.08	0.10	2.34	0.09
26	8.37	0.15	7.50	0.13	4.33	0.12	2.96	0.10	2.25	0.09
27	8.06	0.15	7.22	0.13	4.17	0.12	2.85	0.10	2.17	0.09
28	7.77	0.14	6.96	0.12	4.02	0.11	2.75	0.09	2.09	0.08
29	7.50	0.14	6.72	0.12	3.88	0.11	2.65	0.09	2.02	0.08
30	7.25	0.13	6.50	0.12	3.75	0.10	2.57	0.09	1.95	0.08

Safe loads given, include weight of channel. Maximum fiber strain, 16,000 lbs. per square inch.

SAFE LOADS, UNIFORMLY DISTRIBUTED, FOR CARNEGIE CHANNELS.

IN TONS OF 2,000 LBS.

Distance between supports in feet.	8″ [11 lbs.	Add for every lb. increase in weight.	7″ [9.5 lbs.	Add for every lb. increase in weight.	6″ [8.0 lbs.	Add for every lb. increase in weight.	5″ [6.5 lbs.	Add for every lb. increase in weight.	4″ [5.5 lbs.	Add for every lb. increase in weight.	3″ [5.0 lbs.	Add for every lb. increase in weight.
5	8.47	0.42	6.22	0.37	4.72	.0.31	3.20	0.26	2.17	0.21	1.40	0.16
6	7.06	0.35	5.18	0.31	3.93	0.26	2.67	0.22	1.81	0.17	1.17	0.13
7	6.05	0.30	4.44	0.26	3.37	0.22	2.29	0.19	1.55	0.15	1.00	0.11
8	5.29	0.26	3.89	0.23	2.95	0.20	2.00	0.16	1.36	0.13	0.88	0.10
9	4.71	0.23	3.46	0.20	2.62	0.17	1.78	0.15	1.21	0.12	0.78	0.09
10	4.24	0.21	3.11	0.18	2.36	0.16	1.60	0.13	1.09	0.10	0.70	0.08
11	3.85	0.19	2.83	0.17	2.15	0.14	1.45	0.12	0.99	0.10	0.64	0.07
12	3.53	0.17	2.59	0.15	1.97	0.13	1.33	0.11	0.90	0.09	0.58	0.07
13	3.26	0.16	2.39	0.14	1.82	0.12	1.23	0.10	0.83	0.08	0.54	0.06
14	3.03	0.15	2.22	0.13	1.69	0.11	1.14	0.09	0.78	0.07	0.50	0.06
15	2.82	0.14	2.07	0.12	1.57	0.10	1.07	0.09	0.72	0.07	0.47	0.05
16	2.65	0.13	1.94	0.11	1.48	0.10	1.00	0.08	0.68	0.07	0.43	0.05
17	2.49	0.12	1.83	0.11	1.39	0.09	0.94	0.08	0.64	0.06	0.41	0.05
18	2.35	0.12	1.73	0.10	1.31	0.09	0.89	0.07	0.60	0.06	0.39	0.04
19	2.23	0.11	1.64	0.10	1.24	0.08	0.84	0.07	0.57	0.06	0.37	0.04
20	2.12	0.10	1.56	0.09	1.18	0.08	0.80	0.07	0.54	0.05	0.35	0.04
21	2.02	0.10	1.48	0.09	1.12	0.07	0.76	0.06	0.52	0.05	0.33	0.04
22	1.93	0.09	1.41	0.08	1.07	0.07	0.73	0.06	0.49	0.05	0.32	0.04
23	1.84	0.09	1.35	0.08	1.03	0.07	0.70	0.06	0.47	0.04	0.30	0.03
24	1.76	0.09	1.30	0.08	0.98	0.07	0.67	0.05	0.45	0.04	0.29	0.03
25	1.69	0.08	1.24	0.07	0.94	0.06	0.64	0.05	0.43	0.04	0.28	0.03

Safe loads given include weight of channel. Maximum fiber strain, 16,000 lbs per square inch.

SAFE LOADS, IN TONS OF 2000 LBS., UNIFORMLY DISTRIBUTED, FOR CARNEGIE Z-BARS.

Size, Inches.	Thickness of Metal.	DISTANCE BETWEEN SUPPORTS, IN FEET.									
		4	5	6	7	8	9	10	12	14	16
6	3/8	8.44	6.75	5.63	4.82	4.22	3.75	3.38	2.81	2.41	2.11
6 1/16	7/16	9.83	7.86	6.55	5.61	4.91	4.37	3.93	3.28	2.81	2.46
6 1/8	1/2	11.22	8.98	7.48	6.41	5.61	4.99	4.49	3.74	3.21	2.81
6	9/16	11.55	9.24	7.70	6.60	5.77	5.13	4.62	3.85	3.30	2.89
6 1/16	5/8	12.82	10.26	8.55	7.33	6.41	5.70	5.13	4.27	3.66	3.21
6 1/8	11/16	14.10	11.28	9.40	8.06	7.05	6.27	5.64	4.70	4.03	3.52
6	3/4	14.04	11.23	9.36	8.02	7.02	6.24	5.61	4.68	4.01	3.51
6 1/16	13/16	15.22	12.18	10.15	8.70	7.61	6.77	6.09	5 07	4.35	3.81
6 1/8	7/8	16.40	13.12	10.93	9.37	8.20	7.29	6.56	5.47	4.69	4.10
5	5/16	5.34	4.27	3.56	3.05	2.67	2.37	2.13	1.78	1.52	1.33
5 1/16	3/8	6.39	5.11	4.26	3.65	3.19	2.84	2.55	2.13	1.82	1.60
5 1/8	7/16	7.44	5.95	4.96	4.25	3.72	3.31	2.97	2.48	2.12	1.86
5	1/2	7.67	6.14	5.12	4.39	3.84	3.41	3.07	2.56	2.19	1.92
5 1/16	9/16	8.62	6.90	5.75	4.93	4.31	3.83	3.45	2.87	2.46	2.16
5 1/8	5/8	9.57	7.66	6.38	5.47	4.79	4.25	3.83	3.19	2.74	2.39
5	11/16	9.47	7.58	6.32	5.41	4.74	4.21	3.79	3.16	2.71	2.37
5 1/16	3/4	10.34	8.27	6.89	5.91	5.17	4 59	4.14	3.45	2.95	2.58
5 1/8	13/16	11.20	8.96	7.47	6.40	5.60	4.98	4.48	3.73	3.20	2.80
4	1/4	3.14	2.51	2.09	1.79	1.57	1.39	1.26	1.05	0.90	0.78
4 1/16	5/16	3.91	3.13	2.61	2.24	1.96	1.74	1.56	1.30	1.12	0.98
4 1/8	3/8	4.68	3.74	3.12	2.67	2.34	2.08	1.87	1.56	1.34	1.17
4	7/16	4.83	3.86	3.22	2.76	2.41	2.14	1.93	1.61	1.38	1.21
4 1/16	1/2	5.50	4.40	3.67	3.14	2.75	2.44	2.20	1.83	1.57	1.38
4 1/8	9/16	6.18	4.94	4.12	3.53	3.09	2.74	2.47	2.06	1.76	1.54
4	5/8	6.05	4.84	4.03	3.46	3.02	2.69	2.42	2.02	1.73	1.51
4 1/16	11/16	6.65	5.32	4.43	3.80	3.33	2.96	2.66	2.22	1.90	1.66
4 1/8	3/4	7.26	5.81	4.84	4.15	3.63	3.23	2 90	2.42	2.07	1.82
3	1/4	1.93	1.54	1.28	1.10	0.96	0.86	0.77	0.64	0.55	0.48
3 1/16	5/16	2.38	1.90	1.58	1.36	1.19	1.06	0.95	0.79	0.68	0.59
3	3/8	2.58	2.06	1.72	1.47	1.29	1.14	1.03	0.86	0.74	0.64
3 1/16	7/16	2.98	2.38	1.98	1.70	1.49	1.32	1.19	0.99	0.85	0.74
3	1/2	3.06	2.45	2.04	1.75	1.53	1.36	1.22	1.02	0.88	0.77
3 1/16	9/16	3.43	2.74	2.28	1.96	1.71	1.52	1.37	1.14	0.98	0.86

Safe loads given include weight of Z-bar. Maximum fiber strain, 12,000 lbs. per square inch.

SAFE LOADS IN TONS OF 2,000 POUNDS, UNIFORMLY DISTRIBUTED, FOR CARNEGIE ANGLES, WITH EQUAL LEGS.

Size of Angle.	DISTANCE BETWEEN SUPPORTS, IN FEET.									
	1	2	3	4	5	6	7	8	9	10
6 x6 x7/8	30.56	15.28	10.18	7.64	6.11	5.09	4.37	3.82	3.40	3.06
6 x6 x7/16	16.28	8.14	5.43	4.07	3.26	2.71	2.33	2.04	1.81	1.63
5 x5 x7/8	20.68	10.34	6.89	5.17	4.14	3.45	2.95	2.59	2.30	2.07
5 x5 x3/8	9.68	4.84	3.23	2.42	1.94	1.66	1.38	1.21	1.08	0.97
4 x4 x13/16	12.04	6.02	4.01	3.01	2.41	2.01	1.72	1.51	1.34	1.20
4 x4 x5/16	5.15	2.58	1.72	1.29	1 03	0.86	0.74	0.64	0.57	0.52
3½x3½x13/16	9.00	4.50	3.00	2.25	1.80	1.50	1.29	1.13	1.00	0.90
3½x3½x3/8	4.60	2.30	1.53	1.15	0.92	0.77	0.66	0.58	0.51	0.46
3 x3 x5/8	5.20	2.60	1.73	1.30	1.04	0.87	0.74	0.65	0.58	0.52
3 x3 x¼	2.32	1.16	0.77	0.58	0.46	0.39	0.33	0.29	0.26	0.23
2¾x2¾x½	3.56	1.78	1.19	0.89	0.71	0.59	0.51	0.45	0.40	0.36
2¾x2¾x¼	1.92	0.96	0.64	0.48	0.38	0.32	0.27	0.24	0.21	0.19
2½x2½x½	2.92	1.46	0.97	0.73	0.58	0.49	0.42	0.37	0.32	0.29
2½x2½x¼	1.60	0.80	0.53	0.40	0.32	0.27	0.23	0.20	0.18	0.16
2¼x2¼x½	2.32	1.16	0.77	0.58	0.46	0.39	0.33	0.29	0.26	0.23
2¼x2¼x¼	1.28	0.64	0.43	0.32	0.26	0.21	0.18	0.16	0.14	0.13
2 x2 x7/16	1.60	0.80	0.53	0.40	0.32	0.27	0.23	0.20	0.18	0.16
2 x2 x3/16	0.76	0.38	0.25	0.19	0.15	0.13	0.11	0.095	0.084	0.076
1¾x1¾x7/16	1.20	0.60	0.40	0.30	0.24	0.20	0.17	0.15	0.13	0.12
1¾x1¾x3/16	0.56	0.28	0.19	0.14	0.11	0.093	0.080	0.070	0.062	0.056
1½x1½x3/8	0.76	0.38	0.25	0.19	0.15	0.13	0.11	0.095	0.084	0.076
1½x1½x3/16	0.42	0.21	0.14	0.104	0.083	0.069	0.059	0.052	0.046	0.042
1¼x1¼x5/16	0.44	0.22	0.15	0.109	0.087	0.073	0.062	0.055	0.048	0.044
1¼x1¼x⅛	0.20	0.10	0.065	0.049	0.039	0.033	0.028	0.025	0.022	0.020
1⅛x1⅛x5/16	0.35	0.17	0.12	0.087	0.070	0.058	0.050	0.044	0.039	0.035
1⅛x1⅛x⅛	0.16	0.078	0.052	0.039	0.031	0.026	0.022	0.020	0.017	0.016
1 x1 x¼	0.22	0.11	0.075	0.056	0.045	0.037	0.032	0.028	0.025	0.022
1 x1 x⅛	0.12	0.062	0.041	0.031	0.025	0.021	0.018	0.016	0.014	0.012
⅞x ⅞x3/16	0.13	0.066	0.044	0.033	0.026	0.022	0.019	0.017	0.015	0.013
⅞x ⅞x⅛	0.092	0.046	0.031	0.023	0.018	0.015	0.013	0.012	0.010	0.009
¾x ¾x3/16	0.096	0.048	0.032	0.024	0.019	0.016	0.014	0.012	0.011	0.010
¾x ¾x⅛	0.068	0.034	0.023	0.017	0.014	0.011	0.010	0.009	0.008	0.007
⅝x ⅝x⅛	0.044	0.022	0.015	0.011	0.009	0.007	0.006	0.005	0.005	0.004

Safe loads given include weight of Angle. Maximum fiber strain, 12,000 lbs. per square inch. Neutral axis through centre of gravity parallel to one leg.

SAFE LOADS, IN TONS, OF 2,000 LBS., UNIFORMLY DISTRIBUTED, FOR CARNEGIE ANGLES, WITH UNEQUAL LEGS.

LONG LEG VERTICAL.

Size of Angle.	DISTANCE BETWEEN SUPPORTS, IN FEET.									
	1	2	3	4	5	6	7	8	9	10
$7 \times 3\frac{1}{2} \times 1$	42.32	21.16	14.11	10.58	8.46	7.05	6.05	5.29	4.70	4.23
$7 \times 3\frac{1}{2} \times \frac{7}{16}$	20.04	10.02	6.68	5.01	4.01	3.34	2.86	2.50	2.23	2.00
$6 \times 4 \times \frac{7}{8}$	28.60	14.30	9.53	7.15	5.72	4.77	4.09	3.58	3.18	2.86
$6 \times 4 \times \frac{3}{8}$	13.28	6.64	4.43	3.32	2.66	2.21	1.90	1.66	1.48	1.33
$6 \times 3\frac{1}{2} \times \frac{7}{8}$	27.92	13.96	9.31	6.98	5.58	4.65	3.99	3.49	3.10	2.79
$6 \times 3\frac{1}{2} \times \frac{3}{8}$	13.00	6.50	4.33	3.25	2.60	2.17	1.86	1.63	1.44	1.30
$5 \times 4 \times \frac{7}{8}$	19.96	9.98	6.65	4.99	3.99	3.33	2.85	2.50	2.22	2.00
$5 \times 4 \times \frac{3}{8}$	9.36	4.68	3.12	2.34	1.87	1.56	1.34	1.17	1.04	0.94
$5 \times 3\frac{1}{2} \times \frac{7}{8}$	19.52	9.76	6.51	4.88	3.90	3.25	2.79	2.44	2.17	1.95
$5 \times 3\frac{1}{2} \times \frac{3}{8}$	9.16	4.58	3.05	2.29	1.83	1.53	1.31	1.15	1.02	0.92
$5 \times 3 \times \frac{13}{16}$	17.80	8.90	5.93	4.45	3.56	2.97	2.54	2.23	1.98	1.78
$5 \times 3 \times \frac{5}{16}$	7.50	3.75	2.50	1.88	1.50	1.25	1.07	0.94	0.83	0.75
$4\frac{1}{2} \times 3 \times \frac{13}{16}$	14.48	7.24	4.78	3.62	2.90	2.41	2.07	1.81	1.61	1.45
$4\frac{1}{2} \times 3 \times \frac{3}{8}$	7.32	3.66	2.44	1.83	1.46	1.22	1.05	0.92	0.81	0.73
$4 \times 3\frac{1}{2} \times \frac{13}{16}$	11.68	5.84	3.89	2.92	2.34	1.92	1.67	1.46	1.30	1.17
$4 \times 3\frac{1}{2} \times \frac{3}{8}$	6.00	3.00	2.00	1.50	1.20	1.00	0.86	0.75	0.67	0.60
$4 \times 3 \times \frac{13}{16}$	11.48	5.74	3.83	2.87	2.30	1.91	1.64	1.44	1.28	1.15
$4 \times 3 \times \frac{5}{16}$	4.92	2.46	1.64	1.23	0.98	0.82	0.70	0.62	0.55	0.49
$3\frac{1}{2} \times 3 \times \frac{13}{16}$	8.80	4.40	2.93	2.20	1.76	1.47	1.26	1.10	0.98	0.88
$3\frac{1}{2} \times 3 \times \frac{5}{16}$	3.84	1.92	1.28	0.96	0.77	0.64	0.55	0.48	0.43	0.38
$3\frac{1}{2} \times 2\frac{1}{2} \times \frac{11}{16}$	7.40	3.70	2.47	1.85	1.45	1.23	1.06	0.93	0.82	0.74
$3\frac{1}{2} \times 2\frac{1}{2} \times \frac{1}{4}$	3.00	1.50	1.00	0.75	0.60	0.50	0.43	0.38	0.33	0.30
$3\frac{1}{4} \times 2 \times \frac{9}{16}$	5.20	2.60	1.73	1.30	1.04	0.87	0.74	0.65	0.58	0.52
$3\frac{1}{4} \times 2 \times \frac{1}{4}$	2.52	1.26	0.84	0.63	0.50	0.42	0.36	0.32	0.28	0.25
$3 \times 2\frac{1}{2} \times \frac{9}{16}$	4.60	2.30	1.53	1.15	0.92	0.77	0.66	0.58	0.51	0.46
$3 \times 2\frac{1}{2} \times \frac{1}{4}$	2.24	1.12	0.75	0.56	0.48	0.37	0.32	0.28	0.25	0.22
$3 \times 2 \times \frac{1}{2}$	4.00	2.00	1.33	1.00	0.80	0.67	0.57	0.50	0.44	0.40
$3 \times 2 \times \frac{7}{32}$	1.92	0.96	0.64	0.48	0.38	0.32	0.27	0.24	0.21	0.19
$2\frac{1}{2} \times 2 \times \frac{1}{2}$	2.80	1.40	0.93	0.70	0.56	0.47	0.40	0.35	0.31	0.28
$2\frac{1}{2} \times 2 \times \frac{3}{16}$	1.16	0.58	0.39	0.29	0.23	0.19	0.17	0.15	0.13	0.12
$2\frac{1}{4} \times 1\frac{1}{2} \times \frac{1}{2}$	2.36	1.18	0.79	0.59	0.47	0.39	0.34	0.30	0.26	0.24
$2\frac{1}{4} \times 1\frac{1}{2} \times \frac{3}{16}$	0.92	0.46	0.31	0.23	0.16	0.15	0.13	0.12	0.10	0.09
$2 \times 1\frac{3}{8} \times \frac{1}{4}$	0.92	0.46	0.31	0.23	0.18	0.15	0.13	0.12	0.10	0.09
$2 \times 1\frac{3}{8} \times \frac{3}{16}$	0.72	0.36	0.24	0.18	0.14	0.12	0.10	0.09	0.08	0.07
$1\frac{3}{8} \times 1 \times \frac{7}{32}$	0.36	0.18	0.12	0.09	0.07	0.06	0.05	0.04	0.04	0.03
$1\frac{3}{8} \times 1 \times \frac{1}{8}$	0.24	0.12	0.08	0.06	0.05	0.04	0.03	0.03	0.03	0.02

Safe loads given include weight of Angle. Maximum fiber strain, 12,000 lbs. per square inch. Neutral axis through center of gravity parallel to short leg.

SAFE LOADS, IN TONS OF 2,000 LBS., UNIFORMLY DISTRIBUTED, FOR CARNEGIE ANGLES, WITH UNEQUAL LEGS.

SHORT LEG VERTICAL.

Size of Angle.	DISTANCE BETWEEN SUPPORTS, IN FEET.									
	1	2	3	4	5	6	7	8	9	10
7 x3½x1	11.84	5.92	3.95	2.96	2.37	1.97	1.69	1 48	1.32	1.18
7 x3½x7/16	5.88	2.94	1.96	1.47	1.18	0.98	0.84	0.74	0.65	0.59
6 x4 x⅞	13.56	6.78	4.52	3.39	2.71	2.26	1.94	1.70	1.51	1.36
6 x4 x⅜	6.40	3.20	2.13	1.60	1.28	1.07	0.91	0.80	0.71	0.64
6 x3½x⅞	10.36	5.18	3.45	2.59	2.07	1.73	1.48	1.30	1.15	1.04
6 x3½x⅜	4.92	2.46	1.64	1.23	0.98	0.82	0.70	0.62	0.55	0.49
5 x4 x⅞	13.24	6.62	4.41	3.31	2.65	2.21	1.89	1.66	1.47	1.32
5 x4 x⅜	6.28	3.14	2.09	1.57	1.26	1.05	0.90	0.79	0.70	0.63
5 x3½x⅞	10.08	5.04	3.36	2.52	2.02	1.68	1.44	1.26	1.12	1.01
5 x3½x⅜	4.84	2.42	1.61	1.21	0.96	0.81	0.67	0.61	0.54	0.48
5 x3 x13/16	6.96	3.48	2.32	1.74	1.39	1.16	0.99	0.87	0.77	0.70
5 x3 x5/16	3.00	1.50	1.00	0.75	0.60	0.50	0.43	0.38	0.33	0.30
4½x3 x13/16	6.84	3.42	2.28	1.71	1.37	1.14	0.98	0.86	0.76	0.68
4½x3 x⅜	3.52	1.76	1.17	0.88	0.70	0.59	0.50	0.44	0.39	0.35
4 x3½x13/16	9.20	4.60	3.07	2.30	1.84	1.53	1 31	1.15	1.02	0.92
4 x3½x⅜	4.72	2.36	1.57	1.18	0.94	0.79	0.67	0.59	0.52	0.47
4 x3 x13/16	6.72	3.36	2.24	1.68	1.34	1.12	0.96	0.84	0.75	0.67
4 x3 x5/16	2.96	1.48	0.97	0.74	0.59	0.49	0.42	0.37	0 33	0.30
3½x3 x13/16	6.60	3.30	2.20	1.65	1.32	1.10	0.94	0 83	0.73	0.66
3½x3 x5/16	2.88	1.44	0.96	0.72	0.58	0.48	0.41	0.36	0.32	0.29
3½x2½x11/16	3.96	1.98	1.32	0.99	0.79	0.66	0.57	0.50	0 44	0.40
3½x2½x¼	1.64	0.82	0.55	0.41	0.33	0.27	0.23	0.21	0.18	0.16
3¼x2 x9/16	2.12	1.06	0.71	0.53	0.42	0.35	0.30	0.27	0 24	0.21
3¼x2 x¼	1.04	0.52	0.35	0.26	0 21	0.17	0.15	0.13	0.12	0.10
3 x2½x9/16	3.28	1.64	1.09	0.82	0.66	0.55	0.47	0.41	0.36	0.33
3 x2½x¼	1.60	0.80	0.53	0.40	0.32	0.27	0.23	0.20	0.18	0.16
3 x2 x½	1.88	0.94	0.63	0.47	0.38	0.31	0.27	0.24	0.21	0.19
3 x2 x7/32	0.92	0 46	0.31	0.23	0.18	0.15	0.13	0.12	0.10	0.09
2½x2 x½	1.84	0.92	0.61	0.26	0.37	0.31	0.26	0.23	0.20	0.18
2½x2 x3/16	0.80	0.40	0.27	0.20	0.16	0.13	0 11	0.10	0 09	0.08
2¼x1½x½	1.04	0.52	0.35	0.26	0.21	0.17	0.15	0.13	0.12	0.10
2¼x1½x3/16	0.44	0.22	0.15	0.11	0.09	0.07	0 06	0.06	0.05	0.04
2 x1⅜x¼	0.48	0.24	0.16	0.12	0.10	0.08	0.07	0.06	0.05	0.05
2 x1⅜x3/16	0.36	0.18	0.12	0.09	0.07	0.06	0.05	0.05	0.04	0.04
1⅜x1 x7/32	0.20	0.10	0.07	0.05	0.04	0.03	0.03	0.02	0.02	0.02
1⅜x1 x⅛	0.12	0.06	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01

Safe loads given include weight of Angle. Maximum fiber strain, 12,000 lbs. per square inch Neutral axis through center of gravity parallel to long leg.

SAFE LOADS IN TONS OF 2,000 POUNDS, UNIFORMLY DISTRIBUTED, FOR CARNEGIE TEES

Size Flange by Stem.	Weight per Foot.	DISTANCE BETWEEN SUPPORTS, IN FEET.									
		1	2	3	4	5	6	7	8	9	10
5 x3	13.6	4.72	2.36	1.57	1.18	0.94	0.79	0.67	0.59	0.52	0.47
5 x2½	11.0	3.44	1.72	1.15	0.86	0.69	0.57	0.49	0.43	0.38	0.34
4½x3½	15.8	8.52	4.26	2.84	2.13	1.70	1.42	1.22	1.07	0.95	0.85
4½x3	8.5	3.24	1.62	1.08	0.81	0.65	0.54	0.46	0.41	0.36	0.32
4½x3	10.0	3.76	1.88	1.35	0.94	0.75	0.63	0.54	0.47	0.42	0.38
4½x2½	8.0	2.24	1.12	0.75	0.56	0.45	0.37	0.32	0.28	0.25	0.22
4½x2½	9.3	2.60	1.30	0.87	0.65	0.52	0.43	0.37	0.33	0.29	0.26
4 x5	15.6	12.40	6.20	4.13	3.10	2.48	2.07	1.77	1.55	1.38	1.24
4 x5	12.0	9.72	4.86	3.24	2.43	1.94	1.62	1.39	1.22	1.08	0.97
4 x4½	14.6	10.20	5.10	3.40	2.55	2.04	1.70	1.46	1.28	1.13	1.02
4 x4½	11.4	7.92	3.96	2.64	1.98	1.58	1.32	1.13	0.99	0.88	0.79
4 x4	13.7	8.08	4.04	2.69	2.02	1.63	1.35	1.15	1.01	0.90	0.81
4 x4	10.9	6.56	3.28	2.19	1.64	1.31	1.09	0.94	0.82	0.73	0.66
4 x3	9.3	3.52	1.76	1.17	0.88	0.70	0.59	0.50	0.44	0.39	0.35
4 x2½	8.6	2.48	1.24	0.83	0.62	0.50	0.41	0.35	0.31	0.28	0.25
4 x2½	7.3	2.20	1.10	0.73	0.55	0.44	0.37	0.31	0.28	0.24	0.22
4 x2½	5.8	1.68	0.84	0.56	0.42	0.34	0.28	0.24	0.21	0.19	0.17
4 x2	7.9	1.60	0.80	0.53	0.40	0.32	0.27	0.23	0.20	0.18	0.16
4 x2	6.6	1.36	0.68	0.45	0.34	0.27	0.23	0.19	0.17	0.15	0.14
3½x4	12.8	7.92	3.96	2.64	1.98	1.58	1.32	1.13	0.99	0.88	0.79
3½x4	9.9	6.20	3.10	2.07	1.55	1.24	1.03	0.89	0.78	0.69	0.62
3½x3½	11.7	6.08	3.04	2.03	1.52	1.22	1.01	0.87	0.76	0.68	0.61
3½x3½	9.2	4.76	2.38	1.59	1.19	0.95	0.79	0.68	0.60	0.53	0.48
3½x3½	6.8	3.72	1.86	1.24	0.93	0.74	0.62	0.53	0.47	0.41	0.37
3½x3	11.73	5.72	2.86	1.91	1.43	1.14	0.95	0.82	0.72	0.64	0.57
3½x3	10.9	4.52	2.26	1.51	1.13	0.90	0.75	0.65	0.57	0.50	0.45
3½x3	8.5	3.52	1.76	1.17	0.88	0.70	0.59	0.50	0.44	0.39	0.35
3½x3	7.8	2.88	1.44	0.96	0.72	0.58	0.48	0.41	0.36	0.32	0.29
3 x4	11.8	7.76	3.88	2.59	1.94	1.55	1.29	1.11	0.97	0.86	0.78
3 x4	10 6	7.12	3.56	2.37	1.78	1.42	1.19	1.02	0.89	0.79	0.71
3 x4	9.3	6.28	3.14	2.09	1.57	1.26	1.05	0.90	0.79	0.70	0.63
3 x3½	10.9	5.96	2.98	1.99	1.49	1.19	0.99	0.85	0.75	0.66	0.60
3 x3½	9.8	5.48	2.74	1.83	1.37	1.10	0.91	0.78	0.69	0.61	0.55
3 x3½	8.5	4.84	2.42	1.61	1.21	0.97	0.81	0.69	0.61	0.54	0.48
3 x3	10.0	4.40	2.20	1.47	1.10	0.88	0.73	0.63	0.55	0.49	0.44

Safe loads given include weight of Tee. Maximum fiber strain, 12,000 lbs. per square inch.

SAFE LOADS, IN TONS OF 2,000 POUNDS, UNIFORMLY DISTRIBUTED, FOR CARNEGIE TEES.—Continued.

Size Flange by Stem.	Weight per foot.	DISTANCE BETWEEN SUPPORTS, IN FEET.									
		1	2	3	4	5	6	7	8	9	10
3 x3	9.1	4.04	2.02	1.35	1.01	0.81	0.67	0.58	0.51	0.45	0.40
3 x3	7.8	3.44	1.72	1.15	0.86	0.69	0.57	0.49	0.43	0.38	0.34
3 x3	6.6	2.96	1.48	0.99	0.74	0.59	0.49	0.42	0.37	0.33	0.30
3 x2½	7.2	2.40	1.20	0.80	0.60	0.48	0.40	0.34	0.30	0.27	0.24
3 x2½	6.1	2.08	1.04	0.69	0.52	0.42	0.35	0.30	0.26	0.23	0.21
2¾x2	7.4	3.00	1.50	1.00	0.75	0.60	0.50	0.43	0.38	0.33	0.30
2¾x1¾	6.6	2.00	1.00	0.67	0.50	0.40	0.33	0.29	0.25	0.22	0.20
2½x3	7.2	3.48	1.74	1.16	0.87	0.70	0.58	0.50	0.44	0.39	0.35
2½x3	6.1	3.04	1.52	1.01	0.76	0.61	0.51	0.43	0.38	0.34	0.30
2½x2¾	6.7	2.92	1.46	0.97	0.73	0.58	0.49	0.42	0.37	0.32	0.29
2½x2¾	5.8	2.40	1.20	0.80	0.60	0.48	0.40	0.34	0.30	0.27	0.24
2½x2½	6.4	2.36	1.18	0.79	0.59	0.47	0.39	0.34	0.30	0.26	0.24
2½x2½	5.5	2.00	1.00	0.67	0.50	0.40	0.33	0.29	0.25	0.22	0.20
2½x1¼	2.9	0.36	0.18	0.12	0.09	0.07	0.06	0.05	0.04	0.04	0.03
2¼x2¼	4.9	1.68	0.84	0.56	0.42	0.34	0.28	0.24	0.21	0.19	0.17
2¼x2¼	4.1	1.28	0.64	0.43	0.32	0.26	0.21	0.18	0.16	0.14	0.13
2 x2	4.3	1.32	0.66	0.44	0.33	0.26	0.22	0.19	0.17	0.15	0.13
2 x2	3.7	1.00	0.50	0.33	0.25	0.20	0.17	0.14	0.13	0.11	0.10
2 x1½	3.1	0.60	0.30	0.20	0.15	0.12	0.10	0.09	0.08	0.07	0.06
1¾x1¾	3.1	0.76	0.38	0.25	0.19	0.15	0.13	0.11	0.10	0.08	0.07
1¾x1¼	3.6	0.60	0.30	0.20	0.15	0.12	0.10	0.09	0.08	0.07	0.06
1¾x1¼	1.94	0.32	0.16	0.11	0.08	0.06	0.05	0.05	0.04	0.04	0.03
1½x1½	2.6	0.56	0.28	0.19	0.14	0.11	0.09	0.08	0.07	0.06	0.05
1½x1½	1.84	0.44	0.22	0.15	0.11	0.09	0.07	0.06	0.05	0.05	0.04
1½x1¼	3.0	0.48	0.24	0.16	0.12	0.10	0.08	0.07	0.06	0.05	0.05
1½x1¼	2.24	0.40	0.20	0.13	0.10	0.08	0.07	0.06	0.05	0.04	0.04
1½x1¼	1.73	0.32	0.16	0.11	0.08	0.06	0.05	0.05	0.04	0.04	0.03
1½x1⅛	1.33	0.20	0.10	0.07	0.05	0.04	0.03	0.03	0.02	0.02	0.02
1½x ¾	1.33	0.12	0.06	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01
1¼x1¼	2.04	0.40	0.20	0.13	0.10	0.08	0.07	0.06	0.05	0.04	0.04
1¼x1¼	1.53	0.28	0.14	0.09	0.07	0.06	0.05	0.04	0.03	0.03	0.03
1 x1½	1.12	0.32	0.16	0.11	0.08	0.06	0.05	0.05	0.04	0.04	0.03
1 x1	1.23	0.20	0.10	0.07	0.05	0.04	0.03	0.03	0.02	0.02	0.02
1 x1	0.87	0.12	0.06	0.04	0.03	0.02	0.02	0.02	0.01	0.01	0.01

Safe loads given include weight of Tee. Maximum fiber strain, 12,000 lbs. per square inch.

SPACING OF CARNEGIE I BEAMS FOR UNIFORM LOAD OF 100 LBS. PER SQUARE FOOT.

Proper Distance in Feet, Center to Center of Beams.

Distance between Supports in feet.	20″ I.		15″ I.				12″ I.		10″ I.		9″ I.
	80 lbs.	64 lbs.	80 lbs.	60 lbs.	50 lbs.	41 lbs.	40 lbs.	32 lbs.	33 lbs.	25 lbs.	21 lbs.
12	107.3	84.9	77.6	63.6	52.3	41.9	34.7	27.4	23.9	18.1	13.9
13	91.5	72.3	66.1	54.2	44.6	35.7	29.6	23.4	20.4	15.5	11.8
14	78.8	62.4	57.0	46.7	38.4	30.8	25.5	20.2	17.6	13.3	10.2
15	68.7	54.3	50.0	40.7	33.5	26.8	22.2	17.6	15.3	11.6	8.9
16	60.4	47.7	43.7	35.8	29.4	23.6	19.5	15.4	13.4	10.2	7.8
17	53.5	42.3	38.7	31.7	26.1	20.9	17.3	13.7	11.9	9.0	6.9
18	47.7	37.7	34.5	28.3	23.3	18.6	15.4	12.2	10.6	8.1	6.2
19	42.8	33.9	31.0	25.4	20.9	16.7	13.9	10.9	9.5	7.2	5.5
20	38.6	30.6	28.0	22.9	18.8	15.1	12.5	9.9	8.6	6.5	5.0
21	35.0	27.7	25.3	20.8	17.1	13.7	11.3	8.9	7.8	5.9	4.5
22	31.9	25.3	23.1	18.9	15.6	12.5	10.3	8.2	7.1	5.4	4.1
23	29.2	23.1	21.1	17.3	14.2	11.4	9.5	7.5	6.5	4.9	3.8
24	26.8	21.2	19.4	15.9	13.1	10.5	8.7	6.9	6.0	4.5	3.5
25	24.7	19.6	17.9	14.7	12.1	9.6	8.0	6.3	5.5	4.2	3.2
26	22.9	18.1	16.5	13.6	11.1	8.9	7.4	5.8	5.1	3.9	3.0
27	21.2	16.8	15.3	12.6	10.3	8.3	6.9	5.4	4.7	3.6	2.7
28	19.7	15.6	14.3	11.7	9.6	7.7	6.4	5.0	4.4	3.3	2.6
29	18.4	14.5	13.3	10.9	9.0	7.2	5.9	4.7	4.1	3.1	2.4
30	17.2	13.6	12.4	10.2	8.4	6.7	5.6	4.4	3.8	2.9	2.2

For load of 200 lbs. per square foot, divide the spacing given by 2. Maximum fiber strain, 16,000 lbs. per square inch.

SPACING OF CARNEGIE I BEAMS FOR UNIFORM LOAD OF 100 LBS. PER SQUARE FOOT.

Proper Distance in Feet, Center to Center of Beams.

Distance between supports in feet.	8″ I. 18 lbs.	7″ I. 15 lbs.	6″ I. 13 lbs.	5″ I. 10 lbs.	4″ I. 7 lbs.	3″ I. 6 lbs.
5	61.6	46.3	33.4	21.2	12.1	7.4
6	42.8	32.2	23.2	14.7	8.5	5.2
7	31.4	23.6	17.0	10.8	6.2	3.8
8	24.1	18.1	13.0	8.3	4.8	2.9
9	19.0	14.3	10.3	6.5	3.7	2.3
10	15.4	11.6	8.4	5.3	3.0	1.9
11	12.7	9.6	6.9	4.4	2.5	1.5
12	10.7	8.1	5.8	3.7	2.1	1.3
13	9.1	6.8	4.9	3.1	1.8	1.1
14	7.9	5.9	4.3	2.7	1.6	0.9
15	6.8	5.1	3.7	2.3	1.4	. .
16	6.0	4.5	3.3	2.1	1.2	. .
17	5.3	4.0	2.9	1.8	1.0	. .
18	4.8	3.6	2.6	1.6	0.9	. .
19	4.3	3.2	2.3	1.5	. .	. .
20	3.9	2.9	2.1	1.3	. .	. .
21	3.5	2.6	1.9	1.2	. .	. .
22	3.2	2.4	1.7	1.1	. .	. .

For load of 200 lbs. per square foot, divide the spacing given by 2. Maximum fiber strain, 16,000 lbs. per square inch.

SPACING OF CARNEGIE I BEAMS FOR UNIFORM LOAD OF 125 LBS. PER SQUARE FOOT.

Proper Distance in Feet, Center to Center of Beams.

Distance between supports in feet.	20″ I.		15″ I.				12″ I.		10″ I.		9″ I.
	80 lbs.	64 lbs.	80 lbs.	60 lbs.	50 lbs.	41 lbs.	40 lbs.	32 lbs.	33 lbs.	25 lbs.	21 lbs.
12	85.9	67.9	62.1	50.9	41.8	33.5	27.8	21.9	19.1	14.5	11.1
13	73.2	57.8	52.9	43.4	35.7	28.6	23.7	18.7	16.3	12.4	9.5
14	63.1	49.9	45.6	37.4	30.7	24.6	20.4	16.2	14.1	10.7	8.2
15	55.0	43.5	39.7	32.6	26.8	21.4	17.8	14.1	12.2	9.3	7.1
16	48.3	38.2	34.9	28.6	23.5	18.9	15.6	12.3	10.7	8.2	6.2
17	42.8	33.8	30.9	25.4	20.9	16.7	13.8	11.0	9.5	7.2	5.5
18	38.2	30.2	27.6	22.6	18.6	14.9	12.3	9.8	8.5	6.5	4.9
19	34.2	27.1	24.8	20.3	16.7	13.4	11.1	8.7	7.6	5.8	4.4
20	30.9	24.5	22.4	18.3	15.0	12.1	10.0	7.9	6.9	5.2	4.0
21	28.0	22.2	20.3	16.6	13.7	11.0	9.0	7.1	6.2	4.7	3.6
22	25.5	20.2	18.5	15.1	12.5	10.0	8.2	6.6	5.7	4.3	3.3
23	23.4	18.5	16.9	13.9	11.4	9.1	7.6	6.0	5.2	3.9	3.0
24	21.5	17.0	15.5	12.7	10.5	8.4	7.0	5.5	4.8	3.6	2.8
25	19.8	15.7	14.3	11.7	9.7	7.7	6.4	5.0	4.4	3.3	2.6
26	18.3	14.5	13.2	10.8	8.9	7.1	5.9	4.7	4.1	3.1	2.4
27	17.0	13.4	12.3	10.1	8.2	6.6	5.5	4.3	3.8	2.9	2.2
28	15.8	12.5	11.4	9.3	7.7	6.2	5.1	4.0	3.5	2.7	2.0
29	14.7	11.6	10.6	8.7	7.2	5.8	4.7	3.8	3.3	2.5	1.9
30	13.7	10.9	9.9	8.1	6.7	5.4	4.5	3.5	3.0	2.3	1.8

For load of 250 lbs. per square foot, divide the spacing given by 2. Maximum fiber strain, 16,000 lbs. per square inch.

SPACING OF CARNEGIE I BEAMS FOR UNIFORM LOAD OF 125 LBS. PER SQUARE FOOT.

Proper Distance in Feet, Center to Center of Beams.

Distance between supports in feet.	8″ I.	7″ I.	6″ I.	5″ I.	4″ I.	3″ I.
	18 lbs.	15 lbs.	13 lbs.	10 lbs.	7 lbs.	6 lbs.
5	49.3	37.1	26.7	17.0	9.7	6.0
6	34.2	25.7	18.6	11.8	6.8	4.1
7	25.1	18.9	13.6	8.6	5.0	3.0
8	19.3	14.5	10.4	6.6	3.8	2.3
9	15.2	11.4	8.2	5.2	3.0	1.8
10	12.3	9.3	6.7	4.2	2.4	1.5
11	10.2	7.7	5.5	3.5	2.0	1.2
12	8.6	6.4	4.6	2.9	1.7	1.0
13	7.3	5.5	3.9	2 5	1.4	0.9
14	6.3	4.7	3.4	2.2	1.2	. .
15	5.4	4.1	3.0	1.8	1.1	. .
16	4.8	3.6	2.6	1.7	1.0	. .
17	4.2	3.2	2.3	1.4	. .	. .
18	3.8	2.9	2.1	1.3	. .	. .
19	3.4	2.6	1.8	1.2	. .	. .
20	3.1	2.3	1.7	1.1	. .	. .
21	2.8	2.1	1.5	1.0	. .	. .
22	2.6	1.9	1.4	. .	. .	. .

For load of 250 lbs. per square foot, divide the spacing given by 2. Maximum fiber strain, 16,000 lbs. per square inch.

SPACING OF CARNEGIE I BEAMS FOR UNIFORM LOAD OF 150 LBS. PER SQUARE FOOT.

Proper Distance in Feet, Center to Center of Beams.

Distance between supports in feet.	20″ I.		15″ I.				12″ I.		10″ I.		9″ I.
	80 lbs.	64 lbs.	80 lbs.	60 lbs.	50 lbs.	41 lbs.	40 lbs.	32 lbs.	33 lbs.	25 lbs.	21 lbs.
12	71.5	56.6	51.8	42.4	34.9	27.9	23.1	18.3	15.9	12.1	9.3
13	61.0	48.2	44.1	36.2	29.7	23.8	19.7	15.6	13.6	10.3	7.9
14	52.5	41.6	38.0	31.2	25.6	20.5	17.0	13.5	11.7	8.9	6.8
15	45.8	36.2	33.1	27.2	22.3	17.9	14.8	11.7	10.2	7.7	5.9
16	40.3	31.8	29.1	23.9	19.6	15.7	13.0	10.3	8.9	6.8	5.2
17	35.7	28.2	25.8	21.1	17.4	13.9	11.5	9.1	7.9	6.0	4.6
18	31.8	25.1	23.0	18.9	15.5	12.4	10.3	8.1	7.1	5.4	4.1
19	28.5	22.6	20.6	16.9	14.0	11.1	9.3	7.3	6.3	4.8	3.7
20	25.7	20.4	18.6	15.3	12.5	10.0	8.3	6.6	5.7	4.4	3.3
21	23.3	18.5	16.9	13.8	11.4	9.1	7.5	6.0	5.2	3.9	3.0
22	21.3	16.9	15.4	12.6	10.4	8.3	6.9	5.5	4.7	3.6	2.7
23	19.5	15.4	14.0	11.6	9.5	7.6	6.3	5.0	4.3	3.3	2.5
24	17.9	14.1	12.9	10.6	8.7	7.0	5.8	4.6	4.0	3.0	2.3
25	16.5	13.1	11.9	9.8	8.1	6.4	5.3	4.2	3.7	2.8	2.1
26	15.3	12.1	11.0	9.0	7.4	5.9	4.9	3.9	3.4	2.6	2.0
27	14.1	11.2	10.2	8.4	6.9	5.5	4.6	3.6	3.1	2.4	1.8
28	13.1	10.4	9.5	7.8	6.4	5.1	4.3	3.3	2.9	2.2	1.7
29	12.3	9.7	8.9	7.3	6.0	4.8	3.9	3.1	2.7	2.1	1.6
30	11.5	9.1	8.3	6.8	5.6	4.5	3.7	2.9	2.5	1.9	1.5

For load of 300 lbs. per square foot, divide the spacing given by 2. Maximum fiber strain, 16,000 lbs. per square inch.

SPACING OF CARNEGIE I BEAMS FOR UNIFORM LOAD OF 150 LBS. PER SQUARE FOOT.

Proper Distance in Feet, Center to Center of Beams.

Distance between supports in feet.	8″ I.	7″ I.	6″ I.	5″ I.	4″ I.	3″ I.
	18 lbs.	15 lbs.	13 lbs.	10 lbs.	7 lbs.	6 lbs.
5	41.1	30.9	22.3	14.1	8.1	4.9
6	28 5	21.4	15.5	9.8	5.6	3.4
7	20.9	15.8	11.3	7.2	4.1	2.5
8	16.1	12.1	8.7	5.5	3.2	1.9
9	12.7	9.5	6.9	4.3	2.5	1.5
10	10.3	7.7	5.6	3.5	2.0	1.2
11	8.5	6.4	4.6	2.9	1.7	1.0
12	7.1	5.4	3.9	2.4	1.4	0.9
13	6.1	4.6	3.3	2 1	1.2	. .
14	5.2	3.9	2.8	1.8	1.0	. .
15	4.6	3.4	2.5	1.6	0.9	. .
16	4.0	3.0	2.2	1.4	. .	. .
17	3.5	2.7	1.9	1.2	. .	. .
18	3.2	2.4	1.7	1.1	. .	. .
19	2.9	2.1	1.5	1.0	. .	. .
20	2.6	1.9	1.4	. .	. .	. .
21	2.3	1.7	1.3	. .	. .	. .
22	2.1	1.6	1.1	. .	. .	. .

For load of 300 lbs. per square foot, divide the spacing given by 2. Maximum fiber strain, 16,000 lbs. per square inch.

SPACING OF CARNEGIE I BEAMS FOR UNIFORM LOAD OF 175 LBS. PER SQUARE FOOT.

Proper Distance in Feet, Center to Center of Beams.

Distance between Supports in feet.	20″ I.		15″ I.				12″ I.		10″ I.		9″ I.
	80 lbs.	64 lbs.	80 lbs.	60 lbs.	50 lbs.	41 lbs.	40 lbs.	32 lbs.	33 lbs.	25 lbs.	21 lbs.
12	61.3	48.5	44.4	36.4	29.9	23.9	19.8	15.7	13.7	10.4	7.9
13	52.3	41.3	37.8	31.0	25.5	20.4	16.9	13.4	11.7	8.8	6.8
14	45.0	35.6	32.6	26.7	21.9	17.6	14.6	11.5	10.1	7.6	5.8
15	39.3	31.0	28.4	23.3	19.1	15.3	12.7	10.1	8.7	6.6	5.1
16	34.5	27.3	25.0	20.4	16.8	13.5	11.2	8.8	7.7	5.8	4.5
17	30.6	24.2	22.1	18.1	14.9	11.9	9.9	7.8	6.8	5.2	3.9
18	27.3	21.6	19.7	16.2	13.3	10.6	8.8	7.0	6.1	4.6	3.5
19	24.5	19.4	17.7	14.5	11.9	9.5	7.9	6.2	5.4	4.1	3.1
20	22.1	17.5	16.0	13.1	10.8	8.6	7.1	5.6	4.9	3.7	2.9
21	20.0	15.8	14.5	11.9	9.8	7.8	6.5	5.1	4.5	3.4	2.6
22	18.2	14.4	13.2	10.8	8.9	7.1	5.9	4.7	4.1	3.1	2.3
23	16.7	13.2	12.1	9.9	8.1	6.5	5.4	4.3	3.7	2.8	2.2
24	15.3	12.1	11.1	9.1	7.5	6.0	5.0	3.9	3.4	2.6	2.0
25	14.1	11.2	10.2	8.4	6.9	5.5	4.6	3.6	3.1	2.4	1.8
26	13.1	10.3	9.4	7.7	6.4	5.1	4.2	3.3	2.9	2.2	1.7
27	12.1	9.6	8.8	7.2	5.9	4.7	3.9	3.1	2.7	2.1	1.6
28	11.3	8.9	8.2	6.7	5.5	4.4	3.6	2.9	2.5	1.9	1.5
29	10.5	8.3	7.6	6.2	5.1	4.1	3.4	2.7	2.3	1.8	1.4
30	9.8	7.8	7.1	5.8	4.8	3.8	3.2	2.5	2.2	1.7	1.3

For load of 350 lbs. per square foot, divide the spacing given by 2. Maximum fiber strain, 16,000 lbs. per square inch.

SPACING OF CARNEGIE I BEAMS FOR UNIFORM LOAD OF 175 LBS. PER SQUARE FOOT.

Proper Distance in Feet, Center to Center of Beams.

Distance between supports in feet.	8″ I.	7″ I.	6″ I.	5″ I	4″ I.	3″ I.
	18 lbs.	15 lbs.	13 lbs.	10 lbs.	7 lbs.	6 lbs.
5	35.2	26.5	19.1	12.1	6.9	4.3
6	24.4	18.4	13.3	8.4	4.8	3.0
7	18.0	13.5	9.7	6.2	3.5	2.2
8	13.8	10.3	7.5	4.7	2.7	1.7
9	10.9	8.2	5.9	3.7	2.1	1.3
10	8.8	6.6	4.8	3.0	1.7	1.1
11	7.3	5.5	3.9	2.5	1.4	0.9
12	6.1	4.6	3.3	2.1	1.2	0.7
13	5.2	3.9	2.8	1.8	1.0	. .
14	4.5	3.4	2.4	1.5	0.9	. .
15	3.9	2.9	2.1	1.3	0.8	. .
16	3.4	2.6	1.9	1.2	. .	. .
17	3.0	2.3	1.7	1.0	. .	. .
18	2.7	2.0	1.5	. .	. .	. .
19	2.4	1.8	1.3	. .	. .	. .
20	2.2	1.7	1.2	. .	. .	. .
21	2.0	1.5	1.1	. .	. .	. .
22	1.8	1.4	1.0	. .	. .	. .

For load of 350 lbs. per square foot, divide the spacing given by 2. Maximum fiber strain, 16,000 lbs. per square inch.

EXPLANATION OF TABLES ON THE PROPERTIES OF CARNEGIE I AND DECK BEAMS, CHANNELS, Z BARS, ANGLES, TEES, TROUGH AND CORRUGATED PLATES.

(Pages 99 to 111, inclusive.)

The tables on I-beams are calculated for the minimum weight to which each pattern can be rolled. The tables for Channels, Deck Beams and Angles are calculated for the minimum and maximum weights of the various shapes, while the properties of Z-bars are given for thicknesses differing by $\frac{1}{16}$ inch. The above shapes can all be furnished in any weight intermediate between the minimum and maximum weights given.

For Tees, each shape can be rolled to one weight only.

Columns 11 and 13, in the tables for I and Deck Beams and Channels, give coefficients by the help of which the safe, uniformly distributed load may be readily and quickly determined. To do this, it is only necessary to divide the coefficient given, by the span or distance between supports in feet. If the weight of the section is intermediate between the minimum and maximum weights given, add to the coefficient for the minimum weight, the value given in columns 12 or 14, (for one pound increase of weight,) multiplied by the number of pounds the section is heavier than the minimum.

If a section is to be selected, (as will usually be the case,) intended to carry a certain load, for a length of span already determined on, it will only be necessary to ascertain the coefficient which this load and span will require, and refer to the table for a section having a coefficient of this value. The coefficient is obtained by multiplying the load, in pounds uniformly distributed, by the span length in feet.

In case the load is not uniformly distributed, but is concen-

trated at the middle of the span, multiply the load by 2 and then consider it as uniformly distributed. The deflection will be $\frac{8}{10}$ths of the deflection for the latter load.

For other cases of loading obtain the bending moment in ft. lbs. (the most common cases are given on page 96); this multiplied by 8 will give the coefficient required.

If the loads are quiescent, the coefficients for a fiber strain of 16,000 lbs. per square inch for steel, may be used; but if moving loads are to be provided for, the coefficient for 12,500 lbs. should be taken. Inasmuch as the effects of impact may be very considerable, (the strains produced in an unyielding, inelastic material by a load suddenly applied, being double those produced by the same load in a quiescent state), it will sometimes be advisable to use still smaller fiber strains than those given in the tables. In such cases, the coefficients can readily be determined by proportion. Thus, for a fiber strain of 8,000 lbs. per square inch, the coefficient will equal the coefficient for 16,000 lbs. fiber strain, from the table, divided by 2.

The moments of resistance given in column 9 are used to determine the fiber strain per square inch in a beam, or other shape, subjected to bending or transverse strains, by simply dividing the same into the bending moment expressed in inch-pounds.

The table on the properties of Carnegie T-shapes is modeled after the foregoing, and will, therefore, scarcely require explanation. The horizontal portion of the T is called the flange, and the vertical portion the stem. In the case of the neutral axis parallel to the flange, there will be two moments of resistance, and the smaller is given. The fiber strain calculated from it will, therefore, give the larger of the two strains in the extreme fibers, since these strains are equal to the bending moment divided by the moment of resistance of the section.

For Carnegie Z-bars, complete tables of moments of inertia, moments of resistance, radii of gyration and values of the coefficients (C) are given on pages 101 and 102 for thicknesses varying by $\frac{1}{16}$ inch. These coefficients may be applied, as explained above, for cases where the Z-bars are subjected to transverse loading, as, for example, in the case of roof-purlins. A table of safe loads of Z bars is given on page 77.

For angles, there will be two moments of resistance for each position of the neutral axis, since the distance between the neutral axis and the extreme fibers has a different value on one side of the axis from what it has on the other. The moment of resistance given in the table is the smaller of these two values.

The use of the radii of gyration will be explained in connection with the tables on the strength of wrought iron columns.

Column 15 in the table of the Properties of Carnegie Channels, giving the distance of the center of gravity of channel from the outside of web, is used to obtain the radius of gyration for columns or struts consisting of two channels latticed, as represented by Figs. 11 and 12, page 53, for the case of the neutral axis passing through the center of the cross section parallel to the webs of the channels. This radius of gyration is equal to the distance between the center of gravity of the channel and the center of the section, *i. e.*, neglecting the moments of inertia of the channels around their own axes, thereby introducing a slight error on the side of safety.

These tables have all been prepared with great care. No approximations have entered into any of the calculations, so that the figures given may be relied upon as accurate.

EXAMPLES OF APPLICATION OF TABLES.

I. What section of I-beam will be required to carry 40,000 lbs., uniformly distributed, including its own weight, over a span of 16 feet between supports, allowing a fiber strain of 16,000 lbs. per square inch?

Answer: The coefficient (C) required $= 40{,}000 \times 16 =$ 640,000.

From table for 15″ I—41.0 lbs., C $= 603{,}200$ lbs.; hence the weight of the section must be increased: $\dfrac{640{,}000-603{,}200}{7800}$ $= 4.7$ lbs., *i. e.* the beam required will be a 15″ I-beam, 45.7 lbs. per foot.

II. What load, uniformly distributed, will a 6″ Z-bar carry, weighing 18.3 lbs. per foot and measuring 12 feet between supports, with a maximum fiber strain of 12,000 lbs?

Answer: From table on page 101, the coefficient (C′) for a 6″Z-bar, 18.3 lbs.,=78,600. Hence the safe load=78,600÷12 or 6,550 lbs., including weight of Z-bar.

III. A light 4″ × 3″ angle weighing 7.1 lbs. per foot, spanning 4 feet, is loaded with 1,000 lbs. at center. What will be the maximum fiber strain if the 4″ flange is in a vertical position?

Answer: Bending moment = 12,000 inch-pounds.

From table, moment of resistance = 1.23. Therefore, maximum fiber strain $= \frac{12,000}{1.23}$ or 9,756 lbs., which is the strain furthest from the neutral axis, *i. e.*, at the end of the long flange.

SPECIAL CASES OF LOADING.

I. Beam loaded at a point distant "a" feet from the left hand and "b" from the right hand support by a single load P.

l = length of beam between supports = a + b.

Pressure or *Reaction* at left hand support $= P\frac{b}{l}$ and at right hand support $= P\frac{a}{l}$

Maximum bending moment, neglecting dead weight of beam, occurs at point of application of the load and $= \frac{P\,ab}{l}$

P = (load given in tables, pages 71 to 82) $\times \frac{l^2}{8\,ab}$

When $a = b = \frac{1}{2}l$:

Reaction $= \frac{P}{2}$; *maximum bending moment* $= \frac{Pl}{4}$ and P = load given in tables × ½.

II. Beam fixed at one end and unsupported at the other, l representing the length of beam from end to support.

If loaded by a uniformly distributed load W:

Maximum bending moment occurs at support and $= \frac{W\,l}{2}$

W = (load given in tables, pages 71 to 82) × ¼.

If loaded with a single load P at its extremity:

Maximum bending moment occurs at support and $= Pl$.

P = (load given in tables) × ⅛.

GENERAL FORMULÆ ON THE FLEXURE OF BEAMS OF ANY CROSS-SECTION.

Let A = area of section, in square inches,
l = length of span, in inches,
W = load, uniformily distributed, in lbs.,
M = bending moment, in inch-pounds,
h = height of cross-section, out to out, in inches,
n = distance of center of gravity of section, from top or from bottom, in inches,
s = strain per square inch in extreme fibers of beam, either top or bottom, in lbs., according as n relates to distance from top or from bottom of section.
D = maximum deflection, in inches,
I = moment of inertia of section, neutral axis through center of gravity.
I' = moment of inertia of section, neutral axis parallel to above, but not through center of gravity.
d = distance between these neutral axes.
R = moment of resistance,
r = radius of gyration, in inches,
E = modulus of elasticity, (for wrought iron, assume 27,000,000, for steel, 29,000,000.)

Then: $R = \frac{I}{n}$, $\quad r = \sqrt{\frac{I}{A}}$

$$M = \frac{sI}{n} = sR,$$

$$s = \frac{Mn}{I} = \frac{M}{R},$$

$$W = \frac{8\,sI}{ln} = \frac{8\,s}{l}R,$$

$$s = \frac{Wln}{8I} = \frac{Wl}{8\,R},$$

$$I' = I + Ad^2,$$

$D = \frac{5\,Wl^3}{384\,EI}$ for beam supported at both ends and uniformly loaded.

$D = \frac{Pl^3}{48\,EI}$ for beam supported at both ends and loaded with a single load P at middle.

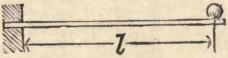
$D = \frac{Wl^3}{8\,EI}$ for beam fixed at one end and unsupported at the other and uniformly loaded.

$D = \frac{Pl^3}{3\,EI}$ for beam fixed at one end and unsupported at other, and loaded with a single load P at the latter end.

BENDING MOMENTS AND DEFLECTIONS OF BEAMS, UNDER VARIOUS SYSTEMS OF LOADING.

W=total load.	I=moment of Inertia.
l=length of beam.	E=modulus of elasticity.

(1.) Beam fixed at one end and loaded at the other.



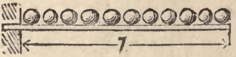
Safe load=⅛ that given in tables.

Maximum bending moment at point of support=Wl.

Maximum shear at points of support=W.

Deflection$=\frac{Wl^3}{3EI}$

(2.) Beam fixed at one end and uniformly loaded.



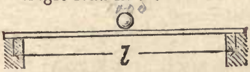
Safe load=¼ that given in tables.

Maximum bending moment at point of support$=\frac{Wl}{2}$

Maximum shear at point of support=W.

Deflection$=\frac{Wl^3}{8EI}$

(3.) Beam supported at both ends, single load in the middle.



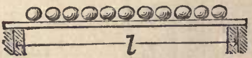
Safe load=½ that given in tables.

Maximum bending moment at middle of beam$=\frac{Wl}{4}$

Maximum shear at points of support=½W.

Deflection$=\frac{Wl^3}{48EI}$

(4.) Beam supported at both ends and uniformly loaded.



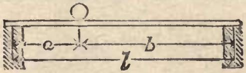
Safe load=that given in tables.

Maximum bending moment at middle of beam$=\frac{Wl}{8}$

Maximum shear at points of support=½W.

Deflection$=\frac{Wl^3}{76.8EI}$

(5.) Beam supported at both ends, single unsymmetrical load.



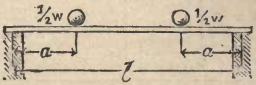
Safe load=that given in tables$\times\frac{l^2}{4ab}$

Maximum bending moment under load$=\frac{Wab}{l}$

Maximum shears: at support near $a=\frac{Wb}{l}$; at other support$=\frac{Wa}{l}$

Max. Deflec.$=\frac{Wab(2l-a)}{9EIl}\sqrt{\tfrac{1}{3}a(2l-a)}$

(6.) Beam supported at both ends, two symmetrical loads.



Safe load=that given in tables$\times\frac{l}{4a}$

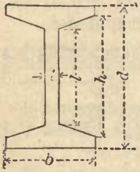
Maximum bending moment between loads=½Wa.

Maximum shear between load and nearer support=½W.

Max. Deflection$=\frac{Wa}{48EI}(3l^2-4a^2)$

VALUES OF MOMENTS OF INERTIA FOR CARNEGIE SHAPES.

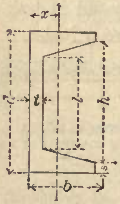
I=Moment of Inertia, neutral axis parallel to flange.
I′= " " " " " " web.



$$\text{Batter}=r=\frac{h-l}{b-t}$$

$$I=\tfrac{1}{12}\left[bd^3-\frac{1}{4r}(h^4-l^4)\right]$$

$$I'=\tfrac{1}{12}\left[b^3(d-h)+lt^3+\frac{r}{4}(b^4-t^4)\right]$$



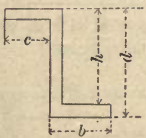
$$\text{Area}=A=2bs+ht+(b-t)\left(\frac{h-l}{2}\right)$$

$$\text{Batter}=r=\frac{h-l}{2(b-t)}$$

$$x=[b^2s+\tfrac{1}{2}ht^2+\tfrac{1}{3}r(b-t)^2(b+2t)]\div A$$

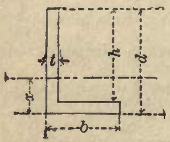
$$I=\tfrac{1}{12}\left[bd^3-\frac{1}{8r}(h^4-l^4)\right]$$

$$I'=\tfrac{1}{3}[2sb^3+lt^3+\tfrac{1}{2}r(b^4-t^4)]-Ax^2$$



$$I=\tfrac{1}{12}\left[bd^3-8c\left(h-\frac{1}{2}d\right)^3\right]$$

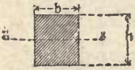
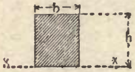
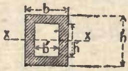
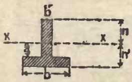
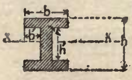
$$I'=\tfrac{1}{12}[d(b+c)^3-2hc^3-6hcb^2]$$



$$x=\frac{t(2h+b)+h^2}{2(h+b)}$$

$$I=\tfrac{1}{3}[bx^3+t(d-x)^3-(b-t)(x-t)^3]$$

VALUES OF I (Moment of Inertia), AND R (Moment of Resistance), FOR USUAL SECTIONS.

SECTIONS.	I	R
	$I=\frac{bh^3}{12}$	$\frac{bh^2}{6}$
	$I'=\frac{bh^3}{3}$	
	$I=\frac{bh^3}{36}$	Min. $=\frac{bh^2}{24}$
	$I'=\frac{bh^3}{12}$	
	$I=\frac{\pi d^4}{64}$ $=0.0491\ d^4$	$\frac{\pi d^3}{32}$ $=0.0982\ d^3$
	$I=\frac{bh^3-b'h'^3}{12}$	$\frac{I}{0.5h}$
	$I=0.0491\ (d^4-d'^4)$	$0.0982\left(d^3-\frac{d'^4}{d}\right)$
	$I=\frac{b'n^3+bn'^3-(b-b')a^3}{3}$	Min. $=\frac{I}{n}$
	$I=\frac{bh^3-2b'h'^3}{12}$	$\frac{I}{0.5h}$

x x Denotes position of neutral axis.

distance from extreme fibres to neutral axis = moment of resistance for either the area below or the area above neutral axis.

PROPERTIES OF CARNEGIE I BEAMS.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Section Index.	Depth of Beam.	Weight per foot. lbs.	Area of Section. sq. in.	Thickness of Web. inches.	Width of Flange. inches.	Increase of Thickness of Web for each lb. increase of wt. inches.	Moment of Inertia, neutral axis perpendicular to web at center. I	Moment of Resistance, neutral axis as before. R	Radius of Gyration, neutral axis as before. r	Coefficient of strength for fiber strain of 16,000 lbs. per square inch. Used for Buildings. C	Add to coefficient for every lb. increase in weight of beam.	Coefficient of strength for fiber, strain of 12,500 lbs. per square inch. Used for Bridges. C′	Add to coefficient for every lb. increase in weight of beam.	Mem. of inertia, neutral axis coincident withcent. line of web. I′	Radius of Gyration, neutral axis as before. r′
B 1	24″	80	23.5	.50	6.95	.0123	2059.3	171.6	9.42	1830500	12800	1430100	10000	41.6	1.34
B 2	20″	80	23.5	.60	7.00	.015	1449.2	144.9	7.85	1545600	10450	1207500	8200	45.6	1.39
B 3	20″	64	18.8	.50	6.25		1146.0	114.6	7.80	1222400		955000		27.3	1.20
B 4	15″	80	23.5	.77	6.41	.020	785.9	104.8	5.82	1117700	7800	873200	6100	42.2	1.35
B 5	15″	60	17.6	.54	6.04		644.0	85.9	6.04	916300		715800		30.4	1.32
B 6	15″	50	14.7	.45	5.75	.020	529.7	70.6	6.00	753300	7800	588500	6100	21.0	1.20
B 7	15″	41	12.0	.40	5.50		424.1	56.6	5.94	603200		471300		14.0	1.08
B 8	12″	40	11.7	.39	5.50	.025	281.3	46.9	4.90	500100	6300	390700	4900	16.8	1.20
B 9	12″	32	9.4	.35	5.25		222.3	37.0	4.85	395200		308800		10.3	1.04
B10	10″	33	9.7	.37	5.00	.029	161.3	32.3	4.08	344000	5200	268800	4100	11.8	1.10
B11	10″	25	7.5	.31	4.74		122.5	24.5	4.06	261200		204000		7.27	0.99
B13	9″	21	6.2	.27	4.50	.033	84.3	18.7	3.70	199900	4600	156100	3600	5.56	0.95
B15	8″	18	5.3	.25	4.25	.037	57.8	14.4	3.30	154000	4200	120300	3300	4.35	0.91
B17	7″	15	4.4	.21	3.98	.042	38.0	10.86	2.92	115800	3600	90500	2800	3.42	0.87
B19	6″	13	3.8	.23	3.50	.049	23.5	7.83	2.48	83500	3100	65300	2400	2.27	0.77
B21	5″	10	3.0	.22	3.00	.059	12.4	4.96	2.05	52900	2600	41300	2000	1.29	0.66
B23	4″	7	2.1	.17	2.59	.074	5.7	2.85	1.66	30400	2100	23800	1600	0.72	0.59
B77	3″	6	1.8	.20	2.26	.098	2.6	1.74	1.21	18560	1560	14500	1220	0.47	0.51

L=Safe Load in lbs. uniformly distributed; l=Span in feet,
M=Moment of forces in foot-lbs.; C and C′=Coefficients given above,

$$\left.\right\} L=\frac{C \text{ or } C'}{l}; \quad M=\frac{C \text{ or } C'}{8}; \quad C \text{ or } C'=L\,l=8\,M.$$

PROPERTIES OF CARNEGIE CHANNELS.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Section Index.	Depth of Channel.	Weight per foot.	Area of Section.	Thickness of Web.	Width of Flange.	Increase of Thickness of Web for each lb. increase of weight.	Moment of Inertia, neutral axis perpendicular to web at center.	Moment of Resistance neutral axis as before.	Radius of Gyration, neutral axis as before.	Coefficient of strength for fiber strain of 16,000 lbs. per square inch. Used for Buildings.	Add to coefficient for every lb. increase in weight of Channel.	Coefficient of strength for fiber strain of 12,500 lbs. per square inch. Used for Bridges.	Add to coefficient for every lb. increase in weight of Channel.	Distance of Center of Gravity from outside of web.
		lbs.	sq. in.	inches.	inches.	inches.	I	R	r	C		C′		Inches.
C1	15″	55.0	16.2	0.84	3.84		427.2	57.0	5.13	607600		474700		0.83
C1	15″	33.0	9.8	0.40	3.40	.020	305.9	40.8	5.60	435200	7800	340000	6100	0.78
C20	13″	52.0	15.3	0.84	4.46		322.4	49.6	4.59	529000		413300		0.99
C20	13″	31.5	9.3	0.38	4.00	.023	237.6	36.5	5.05	389800	6900	304500	5300	1.01
C2	12″	44.0	13.0	0.86	3.46		211.4	35.2	4.03	375800		292600		0.74
C2	12″	20.0	5.9	0.27	2.87	.025	126.6	21.1	4.63	225000	6300	175800	4900	0.71
C3	10″	33.0	9.7	0.75	3.15		112.6	22.5	3.40	240200		187600		0.70
C3	10″	16.5	4.9	0.27	2.67	.029	72.2	14.4	3.85	153900	5200	120300	4100	0.67
C4	9″	25.0	7.4	0.61	2.81		71.3	15.8	3.11	169000		132000		0.63
C4	9″	14.0	4.1	0.25	2.45	.033	49.5	11.0	3.47	117200	4600	91600	3600	0.32
C5	8″	22.0	6.5	0.61	2.61		49.1	12.3	2.75	130800		102200		0.60
C5	8″	11.0	3.2	0.21	2.21	.037	31.8	7.9	3.13	84700	4200	65900	3300	0.58
C6	7″	20.0	5.9	0.65	2.45		33.0	9.4	2.37	100800		78800		0.57
C6	7″	9.5	2.8	0.21	2.01	.042	20.4	5.8	2.71	62200	3600	48600	2800	0.53
C7	6″	16.0	4.7	0.59	2.29		20.4	6.8	2.08	72300		56500		0.55
C7	6″	8.0	2.3	0.20	1.90	.049	13.3	4.4	2.38	47200	3100	37000	2400	0.52
C8	5″	12.0	3.5	0.50	2.10		10.9	4.4	1.77	46400		36200		0.53
C8	5″	6.5	1.9	0.17	1.77	.059	7.5	3.0	1.99	32000	2600	25000	2000	0.52
C9	4″	8.0	2.4	0.35	1.85		5.1	2.5	1.47	27000		21100		0.51
C9	4″	5.5	1.6	0.17	1.67	.074	4.1	2.0	1.59	21700	2100	17000	1600	0.52
C72	3″	6.0	1.8	0.33	1.65		2.2	1.5	1.11	15600		12200		0.51
C72	3″	5.0	1.5	0.23	1.55	.098	2.0	1.3	1.15	14000	1560	11000	1220	0.50

L=Safe Load in lbs. uniformly distributed; l=Span in feet, M=Moment of forces in foot-lbs.; C and C′=Coefficients given above, $\Big\}$ $L=\frac{C \text{ or } C'}{l}$; $M=\frac{C \text{ or } C'}{8}$; C or C′=L l=8 M.

PROPERTIES OF CARNEGIE Z BARS.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
						Moments of Inertia. I		Moments of Resistance R		Radii of Gyration. r			Coefficient of Strength. C	C′
Section Index.	Depth of Web. ins.	Width of Flange. ins.	Thickness of Metal. ins.	Weight per foot. lbs.	Area of Section. sq. in.	Neutral axis through center of gravity perpendicular to web.	Neutral axis through center of gravity coincident with web.	Neutral axis through center of gravity perpendicular to web.	Neutral axis through center of gravity coincident with web.	Neutral axis through center of gravity perpendicular to web.	Neutral axis through center of gravity coincident with web.	Least radius, neutral axis diagonal.	For fiber strain of 16,000 lbs. per sq. in., axis perpendicular to web at center.	For fiber strain of 12,000 lbs. per sq. in., axis perpendicular to web at center.
Z 1	6	3 ½	⅜	15.6	4.59	25.32	9.11	8.44	2.75	2.35	1.41	0.83	90000	67500
Z 1	6 $\frac{1}{16}$	3 $\frac{9}{16}$	$\frac{7}{16}$	18.3	5.39	29.80	10.95	9.83	3.27	2.35	1.43	0.84	104800	78600
Z 1	6 ⅛	3 ⅝	½	21.0	6.19	34.36	12.87	11.22	3.81	2.36	1.44	0.84	119700	89800
Z 2	6	3 ½	$\frac{9}{16}$	22.7	6.68	34.64	12.59	11.55	3.91	2.28	1.37	0.81	123200	92400
Z 2	6 $\frac{1}{16}$	3 $\frac{9}{16}$	⅝	25.4	7.46	38.86	14.42	12.82	4.43	2.28	1.39	0.82	136700	102600
Z 2	6 ⅛	3 ⅝	$\frac{11}{16}$	28.0	8.25	43.18	16.34	14.10	4.98	2.29	1.41	0.84	150400	112800
Z 3	6	3 ½	¾	29.3	8.63	42.12	15.44	14.04	4.94	2.21	1.34	0.81	149800	112300
Z 3	6 $\frac{1}{16}$	3 $\frac{9}{16}$	$\frac{13}{16}$	32.0	9.40	46.13	17.27	15.22	5.47	2.22	1.36	0.82	162300	121800
Z 3	6 ⅛	3 ⅝	⅞	34.6	10.17	50.22	19.18	16.40	6.02	2.22	1.37	0.83	174900	131200
Z 4	5	3 ¼	$\frac{5}{16}$	11.6	3.40	13.36	6.18	5.34	2.00	1.98	1.35	0.75	57000	42700
Z 4	5 $\frac{1}{16}$	3 $\frac{5}{16}$	⅜	13.9	4.10	16.18	7.65	6.39	2.45	1.99	1.37	0.76	68200	51100
Z 4	5 ⅛	3 ⅜	$\frac{7}{16}$	16.4	4.81	19.07	9.20	7.44	2.92	1.99	1.38	0.77	79400	59500

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Z 5	5	$3\frac{1}{4}$	$\frac{1}{2}$	17.8	5.25	19.19	9.05	7.68	3.02	1.91	1.31	0.74	81900	61400
Z 5	$5\frac{1}{16}$	$3\frac{5}{16}$	$\frac{9}{16}$	20.2	5.94	21.83	10.51	8.62	3.47	1.91	1.33	0.75	91900	69000
Z 5	$5\frac{1}{8}$	$3\frac{3}{8}$	$\frac{5}{8}$	22.6	6.64	24.53	12.06	9.57	3.94	1.92	1.35	0.76	102100	76600
Z 6	5	$3\frac{1}{4}$	$\frac{11}{16}$	23.7	6.96	23.68	11.37	9.47	3.91	1.84	1.28	0.73	101000	75800
Z 6	$5\frac{1}{16}$	$3\frac{5}{16}$	$\frac{3}{4}$	26.0	7.64	26.16	12.83	10.34	4.37	1.85	1.30	0.75	110300	82700
Z 6	$5\frac{1}{8}$	$3\frac{3}{8}$	$\frac{13}{16}$	28.3	8.33	28.70	14.36	11.20	4.84	1.86	1.31	0.76	119500	89600
Z 7	4	$3\frac{1}{16}$	$\frac{1}{4}$	8.2	2.41	6.28	4.23	3.14	1.44	1.62	1.33	0.67	33500	25100
Z 7	$4\frac{1}{16}$	$3\frac{1}{8}$	$\frac{5}{16}$	10.3	3.03	7.94	5.46	3.91	1.84	1.62	1.34	0.68	41700	31300
Z 7	$4\frac{1}{8}$	$3\frac{3}{16}$	$\frac{3}{8}$	12.4	3.66	9.63	6.77	4.67	2.26	1.62	1.36	0.69	49800	37400
Z 8	4	$3\frac{1}{16}$	$\frac{7}{16}$	13.8	4.05	9.66	6.73	4.83	2.37	1.55	1.29	0.66	51500	38600
Z 8	$4\frac{1}{16}$	$3\frac{1}{8}$	$\frac{1}{2}$	15.8	4.66	11.18	7.96	5.50	2.77	1.55	1.31	0.67	58700	44000
Z 8	$4\frac{1}{8}$	$3\frac{3}{16}$	$\frac{9}{16}$	17.9	5.27	12.74	9.26	6.18	3.19	1.55	1.33	0.69	65900	49400
Z 9	4	$3\frac{1}{16}$	$\frac{5}{8}$	18.9	5.55	12.11	8.73	6.05	3.18	1.48	1.25	0.66	64500	48400
Z 9	$4\frac{1}{16}$	$3\frac{1}{8}$	$\frac{11}{16}$	20.9	6.14	13.52	9.95	6.65	3.58	1.48	1.27	0.67	70900	53200
Z 9	$4\frac{1}{8}$	$3\frac{3}{16}$	$\frac{3}{4}$	22.9	6.75	14.97	11.24	7.26	4.00	1.49	1.29	0.69	77400	58100
Z10	3	$2\frac{11}{16}$	$\frac{1}{4}$	6.7	1.97	2.87	2.81	1.92	1.10	1.21	1.19	0.55	20500	15400
Z10	$3\frac{1}{16}$	$2\frac{3}{4}$	$\frac{5}{16}$	8.4	2.48	3.64	3.64	2.38	1.40	1.21	1.21	0.56	25400	19000
Z11	3	$2\frac{11}{16}$	$\frac{3}{8}$	9.7	2.86	3.85	3.92	2.57	1.57	1.16	1.17	0.55	27400	20600
Z11	$3\frac{1}{16}$	$2\frac{3}{4}$	$\frac{7}{16}$	11.4	3.36	4.57	4.75	2.98	1.88	1.17	1.19	0.56	31800	23800
Z12	3	$2\frac{11}{16}$	$\frac{1}{2}$	12.5	3.69	4.59	4.85	3.06	1.99	1.12	1.15	0.55	32600	24500
Z12	$3\frac{1}{16}$	$2\frac{3}{4}$	$\frac{9}{16}$	14.2	4.18	5.26	5.70	3.43	2.31	1.12	1.17	0.56	36600	27400

PROPERTIES OF CARNEGIE ANGLE BARS OF MINIMUM AND MAXIMUM THICKNESSES AND WEIGHTS.

ANGLES WITH UNEQUAL LEGS.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Section Index.	Dimensions.	Thickness.	Weight per foot.	Area of Section.	Perpendicular distances from center of gravity to back of flanges.		MOMENTS OF INERTIA. I		MOMENTS OF RESISTANCE. R		RADII OF GYRATION. r		
	inches.	inches.	pounds.	sq in.	To back of longer flange.	To back of shorter flange.	Neutral axis parallel to longer flange.	Neutral axis parallel to shorter flange.	Neutral axis parallel to longer flange.	Neutral axis parallel to shorter flange.	Neutral axis parallel to longer flange.	Neutral axis parallel to shorter flange.	Least Radius. Axis diagonal.
A150	7 ×3½	1	32.3	9.50	0.96	2.71	7.53	45.37	2.96	10.58	0.89	2.19	.88
A159	7 ×3½	7-16	15.0	4.40	0.75	2.50	3.95	22.56	1.47	5.01	0.95	2.26	.89
A160	6 ×4	⅞	27.2	7.99	1.12	2.12	9.75	27.73	3.39	7.15	1.11	1.86	.88
A168	6 ×4	⅜	12.3	3.61	0.94	1.94	4.90	13.47	1.60	3.32	1.17	1.93	.88
A169	6 ×3½	⅞	25.7	7.55	0.97	2.22	6.55	26.38	2.59	6.98	0.93	1.87	.78
A177	6 ×3½	⅜	11.7	3.42	0.79	2.04	3.34	12.86	1.23	3.25	0.99	1.94	.77
A178	5 ×4	⅞	24.2	7.11	1.21	1.71	9.23	16.42	3.31	4.99	1.14	1.52	.88
A186	5 ×4	⅜	11.0	3.23	1.03	1.53	4.67	8.14	1.57	2.34	1.20	1.59	.86
A187	5 ×3½	⅞	22.7	6.67	1.04	1.79	6.21	15.67	2.52	4.88	0.96	1.53	.77
A195	5 ×3½	⅜	10.4	3.05	0.86	1.61	3.18	7.78	1.21	2.29	1.02	1.60	.76
A196	5 ×3	13-16	19.9	5.84	0.86	1.86	3.71	13.98	1.74	4.45	0.80	1.55	.66
A280	5 ×3	5-16	8.2	2.40	0.68	1.68	1.75	6.26	0.75	1.89	0.85	1.61	.66

1	2	3	4	5	6	7	8	9	10	11	12	13	14
A204	4½×3	13-16	18.5	5.43	0.90	1.65	3.60	10.33	1.71	3.62	0.81	1.38	.67
A211	4½×3	⅜	9.1	2.67	0.74	1.49	1.98	5.50	0.88	1.83	0.86	1.44	.66
A212	4 ×3½	13-16	18.5	5.43	1.11	1.36	5.49	7.77	2.30	2.92	1.01	1.19	.74
A219	4 ×3½	⅜	9.1	2.67	0.96	1.21	2.99	4.18	1.18	1.50	1.06	1.25	.73
A220	4 ×3	13-16	17.1	5.03	0.94	1.44	3.47	7.34	1.68	2.87	0.83	1.21	.66
A228	4 ×3	5-16	7.1	2.09	0.76	1.26	1.65	3.38	0.74	1.23	0.89	1.27	.65
A229	3½×3	13-16	15.7	4.62	0.98	1.23	3.33	4.98	1.65	2.20	0.85	1.04	.65
A237	3½×3	5-16	6.6	1.93	0.81	1.06	1.58	2.33	0.72	0.96	0.90	1.10	.63
A238	3½×2½	11-16	12.4	3.65	0.77	1.27	1.72	4.13	0.99	1.85	0.67	1.06	.58
A245	3½×2½	¼	4.9	1.44	0.61	1.11	0.78	1.80	0.41	0.75	0.74	1.12	.55
A246	3¼×2	9-16	9.0	2.64	0.59	1.21	0.75	2.64	0.53	1.30	0.53	1.00	.45
A251	3¼×2	¼	4.3	1.25	0.48	1.09	0.40	1.36	0.26	0.63	0.57	1.04	.44
A252	3 ×2½	9-16	9.5	2.78	0.77	1.02	1.42	2.28	0.82	1.15	0.72	0.91	.54
A257	3 ×2½	¼	4.5	1.31	0.66	0.91	0.74	1.17	0.40	0.56	0.75	0.95	.53
A258	3 ×2	½	7.7	2.25	0.58	1.08	0.67	1.92	0.47	1.00	0.55	0.92	.47
A263	3 ×2	7-32	3.6	1.05	0.48	0.98	0.35	0.97	0.23	0.48	0.58	0.96	.44
A264	2½×2	½	6.8	2.00	0.63	0.88	0.64	1.14	0.46	0.70	0.56	0.75	.44
A269	2½×2	3-16	2.8	0.81	0.51	0.76	0.29	0.51	0.20	0.29	0.60	0.79	.43
A270	2¼×1½	½	5.5	1.63	0.48	0.86	0.26	0.82	0.26	0.59	0.40	0.71	.39
A275	2¼×1½	3-16	2.3	0.67	0.37	0.75	0.12	0.34	0.11	0.23	0.43	0.72	.40
*A276	2 ×1⅜	¼	2.7	0.78	0.37	0.69	0.12	0.37	0.12	0.23	0.39	0.63	.30
*A277	2 ×1⅜	3-16	2.1	0.60	0.35	0.66	0.09	0.24	0.09	0.18	0.40	0.63	.29
A278	1⅜×1	7-32	1.6	0.47	0.29	0.48	0.04	0.08	0.05	0.09	0.28	0.42	.23
A279	1⅜×1	⅛	1.0	0.28	0.26	0.44	0.02	0.05	0.03	0.06	0.29	0.44	.22

PROPERTIES OF CARNEGIE ANGLE BARS OF MAXIMUM AND MINIMUM THICKNESSES AND WEIGHTS.

ANGLES WITH EQUAL LEGS.

1	2	3	4	5	6	7	8	9	10
Section Index.	Dimensions. inches.	Thickness. inches.	Weight per foot.	Area of Section. sq. in.	Distance of center of gravity from back of flange. inches.	Moment of Inertia, neutral axis through center of gravity parallel to flange. I	Moment of Resistance, neutral axis as before. R	Radius of Gyration, neutral axis as before. r	Least Radius of Gyration, neutral axis through center of gravity at angle of 45° to flanges. r′
A 1	6 x6	⅞	33.1	9.74	1.82	31.92	7.64	1.81	1.17
A 8	6 x6	$\frac{7}{16}$	17.2	5.06	1.66	17.68	4.07	1.87	1.19
A 9	5 x5	⅞	27.2	7.99	1.57	17.75	5.17	1.49	0.98
A17	5 x5	⅜	12.3	3.61	1.39	8.74	2.42	1.56	0.99
A18	4 x4	$\frac{13}{16}$	19.9	5.84	1.29	8.14	3.01	1.18	0.80
A90	4 x4	$\frac{5}{16}$	8.2	2.40	1 12	3.71	1.29	1.24	0.82
A26	3½x3½	$\frac{13}{16}$	17.1	5.03	1.17	5.25	2.25	1.02	0.69
A33	3½x3½	⅜	8.5	2.48	1.01	2.87	1.15	1.07	0 70
A34	3 x3	⅝	11.4	3.36	0.98	2,62	1.30	0.88	0.59
A40	3 x3	¼	4.9	1.44	0.84	1.24	0.58	0.93	0.60
A41	2¾x2¾	½	8.5	2.50	0.87	1.67	0.89	0.82	0 54
A45	2¾x2¾	¼	4.5	1.31	0.78	0.93	0.48	0.85	0.55
A46	2½x2½	½	7.7	2.25	0.81	1.23	0.73	0.74	0.49
A50	2½x2½	¼	4.1	1.19	0.72	0.70	0.40	0.77	0.50
A51	2¼x2¼	½	6.8	2.00	0.74	0.87	0.58	0.66	0.48
A55	2¼x2¼	¼	3.7	1.06	0.66	0.51	0.32	0.69	0.46
A56	2 x2	$\frac{7}{16}$	5.3	1.56	0.66	0.54	0.40	0.59	0.39
A60	2 x2	$\frac{3}{16}$	2.5	0.72	0.57	0.28	0 19	0.62	0.40
A61	1¾x1¾	$\frac{7}{16}$	4.6	1.30	0.59	0.35	0.30	0.51	0.35
A65	1¾x1¾	$\frac{3}{16}$	2.1	0.62	0.51	0.18	0.14	0.54	0.36
A66	1½x1½	⅜	3.4	0.99	0.51	0.19	0.19	0.44	0.31
A69	1½x1½	$\frac{3}{16}$	1.8	0.53	0.44	0.11	0.104	0.46	0.32
A70	1¼x1¼	$\frac{5}{16}$	2.4	0.69	0.42	0.09	0.109	0.36	0.25
A73	1¼x1¼	⅛	1.0	0.30	0.35	0.044	0.049	0.38	0.26
A74	1⅛x1⅛	$\frac{5}{16}$	2.1	0.61	0.39	0.063	0.087	0.32	0.24
A77	1⅛x1⅛	⅛	0.9	0 27	0.32	0.032	0.039	0.34	0.23
A78	1 x1	¼	1.5	0.44	0.34	0.037	0.056	0.29	0.20
A80	1 x1	⅛	0.8	0.24	0.30	0.022	0.031	0.31	0.21
A81	⅞x ⅞	$\frac{3}{16}$	1.0	0.29	0.29	0.019	0.033	0.26	0.18
A82	⅞x ⅞	⅛	0.7	0.21	0.26	0.014	0.023	0.26	0.19
A83	¾x ¾	$\frac{3}{16}$	0.8	0.25	0.26	0.012	0.024	0.22	0.16
A84	¾x ¾	⅛	0.6	0.17	0.23	0.009	0.017	0.23	0.17
A85	⅝x ⅝	⅛	0.5	0.14	0.20	0.005	0.011	0.18	0.13

AREAS OF ANGLES VARYING BY $\frac{1}{16}''$ IN THICKNESS.

Size, Inches.	$\frac{5}{16}''$	$\frac{3}{8}''$	$\frac{7}{16}''$	$\frac{1}{2}''$	$\frac{9}{16}''$	$\frac{5}{8}''$	$\frac{11}{16}''$	$\frac{3}{4}''$	$\frac{13}{16}''$	$\frac{7}{8}''$	$\frac{15}{16}''$	$1''$
7 × 3½	..	..	4.40	5.00	5.59	6.17	6.75	7.31	7.87	8.42	8.97	9.50
6 × 6	..	..	5.06	5.75	6.43	7.11	7.78	8.44	9.09	9.74	..	..
6 × 4	..	3.61	4.18	4.75	5.31	5.86	6.41	6.94	7.47	7.99	..	..
6 × 3½	..	3.42	3.97	4.50	5.03	5.55	6.06	6.56	7.06	7.55	..	..
5 × 5	..	3.61	4.18	4.75	5.31	5.86	6.42	6.94	7.46	7.99	..	..
5 × 4	..	3.23	3.75	4.25	4.75	5.23	5.72	6.19	6.65	7.11	..	..
5 × 3½	..	3.05	3.53	4.00	4.47	4.92	5.37	5.81	6.25	6.67	..	..
5 × 3	2.40	2.86	3.31	3.75	4.18	4.61	5.03	5.44	5.84	..	..	..
4½ × 3	..	2.67	3.09	3.50	3.90	4.30	4.68	5.06	5.43	..	..	..
4 × 4	2.40	2.86	3.31	3.75	4.18	4.61	5.03	5.44	5.84	..	..	..
4 × 3½	..	2.67	3.09	3.50	3.90	4.30	4.68	5.06	5.43	..	..	..
4 × 3	2.09	2.48	2.87	3.25	3.62	3.98	4.34	4.69	5.03	..	..	..
3½ × 3½	..	2.48	2.87	3.25	3.62	3.99	4.34	4.69	5.03	..	..	..
3½ × 3	1.93	2.30	2.65	3.00	3.34	3.67	4.00	4.31	4.62	..	..	..

Size, Inches.	$\frac{1}{8}''$	$\frac{3}{16}''$	$\frac{7}{32}''$	$\frac{1}{4}''$	$\frac{5}{16}''$	$\frac{3}{8}''$	$\frac{7}{16}''$	$\frac{1}{2}''$	$\frac{9}{16}''$	$\frac{5}{8}''$	$\frac{11}{16}''$	
3½ × 2½	..	..	..	1.44	1.78	2.11	2.43	2.75	3.06	3.36	3.65	..
3¼ × 2	..	..	..	1.25	1.54	1.83	2.11	2.38	2.64	..	..	..
3 × 3	..	..	..	1.44	1.78	2.11	2.44	2.75	3.06	3.36	..	..
3 × 2½	..	..	..	1.31	1.62	1.92	2.22	2.50	2.78	..	..	..
3 × 2	..	..	1.05	1.19	1.47	1.73	2.00	2.25	..	..	..	..
2¾ × 2¾	..	..	..	1.31	1.62	1.92	2.22	2.50	..	..	..	..
2½ × 2½	..	..	..	1.19	1.47	1.73	2.00	2.25	..	..	..	..
2½ × 2	..	0.81	..	1.06	1.31	1.55	1.78	2.00	..	..	..	..
2¼ × 2¼	..	..	..	1.06	1.31	1.55	1.78	2.00	..	..	..	..
2¼ × 1½	..	0.67	..	0.88	1.07	1.27	1.45	1.63	..	..	..	..
2 × 2	..	0.71	..	0.94	1.15	1.36	1.56	..	..	..	..	..
2 × 1⅜	..	0.60	..	0.78	..	..	..	..	..	..	..	..
1¾ × 1¾	..	0.62	..	0.81	1.00	1.17	1.30	..	..	..	..	..
1½ × 1½	..	0.53	..	0.69	0.84	0.99	..	..	..	..	..	..
1⅜ × 1	0.28	..	0.47	..	..	..	..	..	..	..	..	..
1¼ × 1¼	0.30	0.43	..	0.56	0.69	..	..	..	..	..	..	..
1⅛ × 1⅛	0.27	0.39	..	0.50	0.61	..	..	..	..	..	..	..
1 × 1	0.24	0.34	..	0.44	..	..	..	..	..	..	..	..
⅞ × ⅞	0.21	0 29	..	..	..	..	..	..	..	..	..	..
¾ × ¾	0.17	0.25	..	..	..	..	..	..	..	..	..	..
⅝ × ⅝	0.14	..	..	..	..	..	..	..	..	..	..	..

For weights, see pages 38 to 42.

PROPERTIES OF CARNEGIE DECK BEAMS.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Section Index.	Depth of Beam.	Weight per foot.	Area of Section.	Thickness of Web.	Width of Flange.	Increase of Thickness of Web for each lb. increase of wt.	Moment of Inertia, neutral axis perpendicular to web at center.	Moment of Resistance, neutral axis as before.	Radius of Gyration, neutral axis as before.	Coefficient of strength for fiber strain of 16,000 lbs. per square inch. Used for Buildings.	Add to coefficient for every lb. increase in weight of beam.	Coefficient of strength for fiber strain of 12,000 lbs. per square inch. Used for Bridges.	Add to coefficient for every lb. increase in weight of beam.	Mom. of inertia, neutral axis coincident with cent. line of web.	Radius of Gyrat'on, neutral axis as before.
		lbs.	sq. in.	inches.	inches.	inches.	I	R	r	C		C′		I′	r′
B100	10″	35.70	10.5	.63	5.50		139.9	25.7	3.64	274100		205200		7.41	0.84
B100	10″	27.23	8.0	.38	5.25	.030	118.4	21.2	3.83	226100	4900	169300	3700	6.12	0.87
B101	9″	20.00	8.8	.57	5.07		93.2	19.6	3.25	208500		156400		5.18	0.75
B101	9″	26.00	7.6	.44	4.94	.033	85.2	17.7	3.35	189100	4500	141800	3300	4.61	0.76
B102	8″	24.48	7.2	.47	5.16	.038	62.8	14.1	2.97	150100		112600		4.45	0.79
B102	8″	20.15	5.9	.31	5.00		55.6	12.2	3.08	129800	4000	97400	3000	3.90	0.82
B103	7″	23.46	6.9	.54	5.10	.043	45.5	11.7	2.57	124600		93400		4.30	0.79
B103	7″	18.11	5.3	.31	4.87		38.8	9.7	2.70	103000	3400	77300	2600	3.55	0.82
B105	6″	18.36	5.4	.43	4.53		26.8	8.2	2.25	87700		65800		2.73	0.72
B105	6″	15.30	4.5	.28	4.38	.050	24.0	7.3	2.33	77400	3000	58000	2200	2.38	0.73

BULB ANGLES.

Coefficients C and C′ calculated for Fiber Strains of 16,000 and 12,500 lbs. per square inch respectively.

B130	10″	26.50	7.80	.48	3.5	. .	104.2	19.9	3.66	211700	. .	165400	. .	. .	. .
B131	9″	21.80	6.41	.44	3.5	. .	69.3	14.5	3.33	154200	. .	120500	. .	. .	. .
B132	8″	19.23	5.66	.41	3.5	. .	48.8	11.7	2.95	124800	. .	97500	. .	. .	. .
B133	7″	18.25	5.37	.44	3.0	. .	34.9	9.6	2.56	102300	. .	79900	. .	. .	. .
B134	6″	17.20	5.06	.50	3.0	. .	23.9	7.6	2.16	80500	. .	62900	. .	. .	. .
B135	6″	13.75	4.04	.38	3.0	. .	20.1	6.6	2.21	70400	. .	55000	. .	. .	. .
B136	6″	12.30	3.62	.31	3.0	. .	18.6	5.7	2.28	60400	. .	47200	. .	. .	. .
B137	5″	10.00	2.94	.31	2.5	. .	10.2	4.1	1.86	43300	. .	33800	. .	. .	. .

PROPERTIES OF CARNEGIE T SHAPES.

1	2	3	4	5	6	7	8	9	10	11	12	13
Section Index.	Size: Flange by Stem.	Weight per foot.	Area of Section.	Distance of Center of Gravity from outside of Flange.	Moment of Inertia, neutral axis through center of gravity parallel to Flange.	Least moment of Resistance, neutral axis as before.	Radius of Gyration, neutral axis as before.	Mom. of Inertia, neutral axis through center of gravity coincident with stem.	Moment of Resistance, neutral axis as before.	Radius of Gyration, neutral axis as before.	Coeffic't of strength for fiber strain of 12,000 lbs. per square inch, neutral axis through ctr. of gravity parallel to flange.	Coefficient of strength for fiber strain of 10,000 lbs. per square inch, neutral axis as before.
	inches.	pounds.	sq. in.	inches.	I	R	r	I′	R′	r′	C_1	C_2
T50	5 ×3	13.6	3.99	0.75	2.6	1.18	0.82	5.6	2.22	1.19	9410	7840
T51	5 ×2½	11.0	3.24	0.65	1.6	0.86	0.71	4.3	1.70	1.16	6900	5750
T52	4½×3½	15.8	4.65	1.11	5.1	2.13	1.04	3.7	1.65	0.90	17020	14180
T53	4½×3	8.5	2.55	0.73	1.8	0.81	0.87	2.6	1.16	1.03	6490	5410
T54	4½×3	10.0	3.00	0.75	2.1	0.94	0.86	3.1	1.38	1.04	7540	6280
T55	4½×2½	8.0	2.40	0.58	1.1	0.56	0.69	2.6	1.16	1.07	4520	3760
T56	4½×2½	9.3	2.79	0.60	1.2	0.65	0.68	3.1	1.38	1.08	5230	4360
T57	4 ×5	15.6	4.56	1.56	10.7	3.10	1.54	2.8	1.41	0.79	24800	20670
T58	4 ×5	12.0	3.54	1.51	8.5	2.43	1.56	2.1	1.06	0.78	19410	16180
T59	4 ×4½	14.6	4.29	1.37	8.0	2.55	1.37	2.8	1.41	0.81	20400	17000
T60	4 ×4½	11.4	3.36	1.31	6.3	1.98	1.38	2.1	1.06	0.80	15840	13200
T 1	4 ×4	13.7	4.02	1.18	5.7	2.02	1.20	2.8	1.40	0.84	16190	13490
T 2	4 ×4	10.9	3.21	1.15	4.7	1.64	1.23	2.2	1.09	0.84	13100	10920
T61	4 ×3	9.3	2.73	0.78	2.0	0.88	0.86	2.1	1.05	0.88	7070	5900
T62	4 ×2½	8.6	2.52	0.63	1.2	0.62	0.69	2.1	1.05	0.92	4980	4150
T63	4 ×2½	7.3	2.16	0.60	1.0	0.55	0.70	1.8	0.88	0.91	4380	3650
T63	4 ×2½	5.8	1.71	0.56	0.81	0.42	0.71	1.4	0.71	0.94	3350	2790
T64	4 ×2	7.9	2.31	0.48	0.60	0.40	0.52	2.1	1.05	0.96	3180	2650
T65	4 ×2	6.6	1.95	0.51	0.54	0.34	0.51	1.8	0.88	0.95	2700	2250

PROPERTIES OF CARNEGIE T SHAPES.

1	2	3	4	5	6	7	8	9	10	11	12	13
Section Index.	Size Flange by Stem. inches.	Weight per foot. pounds.	Area of Section. sq. in.	Distance of Center of Gravity from outside of Flange. inches.	Moment of Inertia, neutral axis through center of gravity parallel to Flange. I	Least moment of Resistance, neutral axis as before. R	Radius of Gyration, neutral axis as before. r	Mom. of Inertia, neutral axis through center of gravity coincident with stem. I′	Moment of Resistance, neutral axis as before. R′	Radius of Gyration, neutral axis as before. r′	Coeffic't of strength for fiber strain of 12,000 lbs. per square inch, neutral axis through ctr. of gravity parallel to flange. C	Coefficient of strength for fiber strain of 10,000 lbs. per square inch, neutral axis as before. C
T66	3½×4	12.8	3.75	1.25	5.5	1.98	1.21	1.89	1.08	0.72	15870	13220
T67	3½×4	9.9	2.91	1.19	4.3	1.55	1.22	1.42	0.81	0.70	12380	10310
T 3	3½×3½	11.7	3.45	1.06	3.7	1.52	1.04	1.89	1.08	0.74	12000	10000
T 4	3½×3½	9.2	2.70	1.01	3.0	1.19	1.05	1.42	0.81	0.73	9530	7940
T 5	3½×3½	6.8	2.04	0.98	2.3	0.93	1.09	1.07	0.61	0.73	7450	6210
T68	3½×3	11.73	3.45	1.01	2.9	1.43	0.92	1.74	1.00	0.72	11470	9560
T69	3½×3	10.9	3.21	0.88	2.4	1.13	0.87	1.88	1.08	0.77	9050	7540
T70	3½×3	8.5	2.49	0.83	1.9	0.88	0.88	1.41	0.81	0.75	7040	5870
T71	3½×3	7.8	2.28	0.78	1.6	0.72	0.89	1.18	0.68	0.76	5790	4830
T72	3 ×4	11.8	3.48	1.32	5.2	1.94	1.23	1.21	0.81	0.59	15480	12900
T73	3 ×4	10.6	3.12	1.32	4.8	1.78	1.25	1.09	0.72	0.60	14270	11890
T74	3 ×4	9.3	2.73	1.29	4.3	1.57	1.26	0.93	0.62	0.59	12540	10450
T75	3 ×3½	10.9	3.21	1.12	3.5	1.49	1.06	1.20	0.80	0.62	11910	9920
T76	3 ×3½	9.8	2.88	1.11	3.3	1.37	1.08	1.31	0.88	0.68	10990	9160
T77	3 ×3½	8.5	2.49	1.09	2.9	1.21	1.09	0.93	0.62	0.61	9680	8670
T 6	3 ×3	10.0	2.94	0.93	2.3	1.10	0.88	1.20	0.80	0.64	8780	7320
T 7	3 ×3	9.1	2.67	0.92	2.1	1.01	0.90	1.08	0.72	0.64	8110	6760
T 8	3 ×3	7.8	2.28	0.83	1.8	0.86	0.90	0.90	0.60	0.63	6900	5750

T 9	3 ×3	6.6	1.95	0.86	1.6	0.74	0.90	0.75	0.50	0.62	5900	4900
T78	3 ×2½	7.2	2.10	0.71	1.1	0.60	0.72	0.89	0.60	0.66	4800	4000
T79	3 ×2½	6.1	1.80	0.68	0.94	0.52	0.73	0.75	0.50	0.65	4100	3450
T80	2¾×2	7.4	2.16	0.53	1.1	0.75	0.71	0.62	0.45	0.54	6000	5000
T81	2¾×1¾	6.6	1.95	0.64	0.56	0.50	0.53	0.61	0.44	0.56	4000	3350
T82	2½×3	7.2	2.10	0.97	1.8	0.87	0.92	0.54	0.43	0.51	6960	5800
T83	2½×3	6.1	1.80	0.92	1.6	0.76	0.94	0.44	0.35	0.51	6110	5090
T84	2½×2¾	6.7	1.98	0.87	1.4	0.73	0.84	0.66	0.53	0.58	5860	4890
T85	2½×2¾	5.8	1.71	0.83	1.2	0.60	0.83	0.44	0.35	0.51	4830	4030
T10	2½×2½	6.4	1.89	0.76	1.0	0.59	0.74	0.52	0.42	0.53	4700	3900
T11	2½×2½	5.5	1.62	0.74	0.87	0.50	0.74	0.44	0.35	0.52	4000	3300
T86	2½×1¼	2.9	0.84	0.29	0.85	0.09	0.31	0.29	0.23	0.58	700	580
T12	2¼×2¼	4.9	1.44	0.69	0.66	0.42	0.68	0.33	0.30	0.48	3360	2800
T13	2¼×2¼	4.1	1.20	0.66	0.51	0.32	0.67	0.25	0.22	0.47	2600	2150
T14	2 ×2	4.3	1.26	0.63	0.45	0.33	0.60	0.23	0.23	0.43	2610	2170
T15	2 ×2	3.7	1.08	0.59	0.36	0.25	0.60	0.18	0.18	0.42	2000	1700
T87	2 ×1½	3.1	0.90	0.42	0.16	0.15	0.42	0.18	0.18	0.45	1200	970
T16	1¾×1¾	3.1	0.90	0.54	0.23	0.19	0.51	0.12	0.14	0.37	1550	1300
T88	1¾×1¼	3.6	1.05	0.91	0.12	0.15	0.33	0.19	0.22	0.41	1150	970
T89	1¾×1¼	1.94	0.57	0.33	0.07	0.08	0.35	0.09	0.11	0.40	620	510
T17	1½×1½	2.6	0.75	0.42	0.15	0.14	0.49	0.08	0.10	0.34	1150	950
T18	1½×1½	1.84	0.54	0.44	0.11	0.11	0.45	0.06	0.07	0.31	860	720
T90	1½×1¼	3.0	0.87	0.40	0.10	0.12	0.35	0.10	0.13	0.34	940	780
T91	1½×1¼	2.24	0.66	0.38	0.09	0.10	0.36	0.08	0.10	0.34	785	655
T92	1½×1¼	1.73	0.51	0.35	0.07	0.08	0.36	0.06	0.07	0.33	600	500
T93	1½×1⅛	1.33	0.39	0.35	0.04	0.05	0.33	0.03	0.04	0.29	420	350
T94	1½× ¾	1.33	0.39	0.20	0.01	0.03	0.19	0.05	0.07	0.37	210	170
T19	1¼×1¼	2.04	0.60	0.40	0.08	0.10	0.36	0.05	0.07	0.27	760	630
T20	1¼×1¼	1.53	0.45	0.38	0.06	0.07	0.37	0.03	0.05	0.26	580	490
T95	1 ×1½	1.12	0.33	0.50	0.08	0.08	0.48	0.01	0.02	0.19	605	505
T21	1 ×1	1.23	0.36	0.32	0.03	0.05	0.29	0.02	0.04	0.21	370	310
T22	1 ×1	0.87	0.26	0.29	0.02	0.03	0.29	0.01	0.02	0.21	270	230

PROPERTIES OF CARNEGIE TROUGH PLATES.

Section Index.	Size in inches.	Thickness in inches.	WEIGHT.	Area in sq. inches.	Moment of Inertia neutral axis parallel to length. I	Moment of Resistance, axis as before. R	Radius of Gyration, axis as before. r
M 10	$9\frac{1}{2} \times 3\frac{3}{4}$	$\frac{1}{2}$	16.32	4.8	3.68	1.38	0.91
M 11	$9\frac{1}{2} \times 3\frac{3}{4}$	$\frac{9}{16}$	18.02	5.3	4.13	1.57	0.91
M 12	$9\frac{1}{2} \times 3\frac{3}{4}$	$\frac{5}{8}$	19.72	5.8	4.57	1.77	0.90
M 13	$9\frac{1}{2} \times 3\frac{3}{4}$	$\frac{11}{16}$	21.42	6.3	5.02	1.96	0.90
M 14	$9\frac{1}{2} \times 3\frac{3}{4}$	$\frac{3}{4}$	23.15	6.8	5.46	2.15	0.90

PROPERTIES OF CARNEGIE CORRUGATED PLATES.

Section Index.	Size in inches.	Thickness in inches.	WEIGHT.	Area in sq. inches.	Moment of Inertia neutral axis parallel to length. I	Moment of Resistance, axis as before. R	Radius of Gyration, axis as before. r
M 30	$8\frac{3}{4} \times 1\frac{1}{2}$	$\frac{1}{4}$	8.06	2.4	0.64	0.80	0.52
M 31	$8\frac{3}{4} \times 1\frac{1}{2}$	$\frac{5}{16}$	10.10	3.0	0.95	1.13	0.57
M 32	$8\frac{3}{4} \times 1\frac{1}{2}$	$\frac{3}{8}$	12.04	3.5	1.25	1.42	0.62
M 33	$12\frac{3}{16} \times 2\frac{3}{4}$	$\frac{3}{8}$	17.75	5.2	4.79	3 33	0.96
M 34	$12\frac{3}{16} \times 2\frac{3}{4}$	$\frac{7}{16}$	20.71	6.1	5.81	3.90	0.98
M 35	$12\frac{3}{16} \times 2\frac{3}{4}$	$\frac{1}{2}$	23.67	7.0	6.82	4.46	0.99

EXPLANATION OF TABLES ON BEAM BOX GIRDERS.

An economical style of box girder, well adapted for short span lengths, is one composed of a pair of I-beams with top and bottom flange plates. Such girders are commonly used for supporting interior walls in buildings. The tables are prepared to conform with standard sizes of Carnegie I-beams.

The values given in the tables are founded upon the moments of inertia of the various sections. Deductions were made for the rivet holes in both flanges. The maximum strain in extreme fibers was limited to 13,000 lbs. per square inch, while in the tables on rolled steel beams a fiber strain of 16,000 lbs. was used. This reduction was made in order to amply compensate for the deterioration of the metal around the rivet holes from punching.

Box girders should not be used in damp or exposed places, since the interior surfaces do not readily admit of repainting.

EXAMPLE.

A 13″ brick wall, 15 feet high, is to be built over an opening of 24 feet. What will be the section of the girder required?

Answer:—Assuming 25 feet as the distance, center to center of bearings, the weight of the wall will be $25 \times 15 \times 121 = 45{,}375$ lbs., or 22.68 tons.

On page 114 we find that a girder composed of two 12″ beams, each weighing 32.0 lbs. per foot, and two 14″ × ½″ flange plates will carry safely, for a span of 25 feet, a uniformly distributed load of 23.23 tons, including its own weight. Deducting the latter, 1.42 tons, given in the next column, we find 21.81 tons for the value of the safe net load, which is 1.07 tons less than required. From the following column we find that by increasing the thickness of the flange plates $\frac{1}{16}$″ we may add 1.52 tons to the allowable load. This will more than cover the difference. Hence the required section will be two 12″ beams 32.0 lbs. per foot, and two 14″ × $\frac{9}{16}$″ cover plates.

BEAM BOX GIRDERS.

SAFE LOADS IN TONS, UNIFORMLY DISTRIBUTED.

2–10″ I Beams and 2 Plates 12″ × ½″

2 plates, 12×½

10″ I Beams, 33.0 lbs. per foot.

2 plates, 12×½

10″ I Beams, 25.0 lbs. per foot.

Distance, center to center of bearings, in feet.	10″ I Beams, 33.0 lbs. per foot: Safe load uniformly distributed (including weight of girder) in tons of 2,000 lbs.	Weight of girder (including rivet heads) in tons of 2,000 lbs.	Increase in safe load for 1-16 increase in thickness of flange plates.	10″ I Beams, 25.0 lbs. per foot: Safe load uniformly distributed (including weight of girder) in tons of 2,000 lbs.	Weight of girder (including rivet heads) in tons of 2,000 lbs.	Increase in safe load for 1-16 increase in thickness of flange plates.	Increase in weight of girder for 1-16″ increase in thickness of flange plates.
10	44.35	0.55	2.59	38.97	0.47	2.64	0.02
11	40.32	0.60	2.36	35.42	0.52	2.40	0.03
12	36.96	0.65	2.16	32.47	0.56	2.20	0.03
13	34.12	0.71	1.99	29.98	0.61	2.03	0.03
14	31.68	0.76	1.85	27.83	0.66	1.89	0.03
15	29.57	0.82	1.73	25.98	0.71	1.76	0.04
16	27.72	0.87	1.62	24.38	0.75	1.65	0.04
17	26.09	0.93	1.52	22.93	0.80	1.55	0.04
18	24.64	0.98	1.44	21.64	0.85	1.47	0.04
19	23.34	1.04	1.36	20.51	0.89	1.39	0.05
20	22.18	1.09	1.30	19.49	0.93	1.32	0.05
21	21.12	1.15	1.23	18.56	0.98	1.26	0.05
22	20.16	1.20	1.18	17.71	1.03	1.20	0.05
23	19.28	1.26	1.13	16.95	1.07	1.15	0.06
24	18.48	1.31	1.08	16.24	1.12	1.10	0.06
25	17.74	1.36	1.04	15.59	1.17	1.06	0.06
26	17.06	1.42	1.00	15.00	1.21	1.02	0.06
27	16.43	1.47	0.96	14.43	1.26	0.98	0.07
28	15.84	1.53	0.93	13.92	1.31	0.94	0.07
29	15.29	1.58	0.89	13.44	1.36	0.91	0.07
30	14.78	1.64	0.86	13.00	1.40	0.88	0.07
31	14.31	1.69	0.84	12.57	1.45	0.85	0.08
32	13.86	1.75	0.81	12.18	1.50	0.82	0.08
33	13.44	1.80	0.78	11.81	1.54	0.80	0.08
34	13.04	1.86	0.76	11.46	1.59	0.78	0.08
35	12.67	1.91	0.74	11.14	1.64	0.75	0.09
36	12.32	1.96	0.72	10.83	1.69	0.73	0.09
37	11.99	2.02	0.70	10.53	1.73	0.71	0.09
38	11.67	2.07	0.68	10.25	1.78	0.69	0.09
39	11.37	2.13	0.66	10.00	1.83	0.67	0.10

Above values are based on maximum fiber strains of 13,000 lbs. per sq. in.; $\frac{13}{16}$″ rivet holes in both flanges deducted. Weights of girders correspond to lengths, center to center of bearings.

BEAM BOX GIRDERS.

SAFE LOADS IN TONS, UNIFORMLY DISTRIBUTED.

2–12″ I Beams and 2 Plates 14″ × ½″

Distance, center to center of bearings, in feet.	2 plates, 14×½; 12″ I Beams, 40.0 lbs. per foot.			2 plates, 14×½; 12″ I Beams, 32.0 lbs. per foot.			Increase in weight of girder for 1-16″ increase in thickness of flange plates.
	Safe load uniformly distributed (including weight of girder) in tons of 2,000 lbs.	Weight of girder (including rivet heads) in tons of 2,000 lbs.	Increase in safe load for 1-16 increase in thickness of flange plates.	Safe load uniformly distributed (including weight of girder) in tons of 2,000 lbs.	Weight of girder (including rivet heads) in tons of 2,000 lbs.	Increase in safe load for 1-16 increase in thickness of flange plates.	
10	64.94	0.65	3.75	58.08	0.57	3.81	0.03
11	59.02	0.71	3.40	52.80	0.63	3.45	0.03
12	54.12	0.78	3.12	48.40	0.68	3.17	0.03
13	49.95	0.84	2.88	44.68	0.74	2.93	0.04
14	46.39	0.91	2.68	41.48	0.80	2.72	0.04
15	43.29	0.97	2.50	38.72	0.85	2.53	0.04
16	40.59	1.04	2.34	36.30	0.91	2.38	0.05
17	38.20	1.10	2.21	34.16	0.97	2.24	0.05
18	36.08	1.17	2.08	32.27	1.03	2.11	0.05
19	34.18	1.23	1.97	30.57	1.08	2.00	0.05
20	32.47	1.30	1.87	29.04	1.14	1.90	0.06
21	30.93	1.36	1.78	27.66	1.20	1.81	0.06
22	29.52	1.43	1.70	26.40	1.25	1.73	0.06
23	28.23	1.49	1.63	25.25	1.31	1.65	0.07
24	27.06	1.56	1.56	24.20	1.37	1.58	0.07
25	25.98	1.62	1.50	23.23	1.42	1.52	0.07
26	24.98	1.69	1.44	22.34	1.48	1.46	0.08
27	24.05	1.75	1.38	21.51	1.54	1.41	0.08
28	23.19	1.82	1.34	20.74	1.60	1.36	0.08
29	22.39	1.88	1.29	20.03	1.65	1.31	0.08
30	21.65	1.95	1.25	19.36	1.71	1.27	0.09
31	20.95	2.01	1.21	18.73	1.77	1.23	0.09
32	20.29	2.08	1.17	18.15	1.82	1.19	0.09
33	19.68	2.14	1.14	17.60	1.88	1.15	0.10
34	19.10	2.21	1.10	17.08	1.94	1.12	0.10
35	18.55	2.27	1.07	16.59	1.99	1.09	0.10
36	18.04	2.34	1.04	16.13	2.05	1.06	0.10
37	17.55	2.40	1.01	15.70	2.11	1.03	0.11
38	17.09	2.47	0.99	15.28	2.17	1.00	0.11
39	16.65	2.53	0.96	14.89	2.22	0.98	0.11

Above values are based on maximum fiber strains of 13,000 lbs. per sq. in.; $\frac{13}{16}$″ rivet holes in both flanges deducted. Weights of girders correspond to lengths, center to center of bearings.

BEAM BOX GIRDERS.

SAFE LOADS IN TONS, UNIFORMLY DISTRIBUTED.

2–15″ I Beams and 2 Plates 14″ × ⅝″

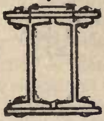
Distance center to center of bearings, in feet.	6¾″  15″ I. 80.0 lbs. per foot. Plates, 14″×⅝″		6½″  15″ I. 60.0 lbs. per foot. Plates, 14″×⅝″		6″  15″ I. 41.0 lbs. per foot. Plates, 14″×⅝″		Increase in safe load for 1-16″ increase in thickness of flange plates.	Increase in weight of girder for 1-16″ increase in thickness of flange plates.
	Safe load uniformly distributed (including weight of girder) in tons of 2,000 lbs.	Weight of girder (including rivet heads) in tons of 2,000 lbs.	Safe load uniformly distributed (including weight of girder) in tons of 2,000 lbs.	Weight of girder (including rivet heads) in tons of 2,000 lbs.	Safe load uniformly distributed (including weight of girder) in tons of 2,000 lbs.	Weight of girder (including rivet heads) in tons of 2,000 lbs.		
10	125.45	1.11	111.01	0.91	90.29	0.72	4.63	0.03
11	114.05	1.22	100.92	1.00	82.08	0.79	4.21	0.03
12	104.55	1.33	92.51	1.09	75.24	0.86	3.86	0.03
13	96.50	1.44	85.40	1.18	69.45	0.93	3.57	0.04
14	89.61	1.55	79.30	1.27	64.50	1.00	3.31	0.04
15	83.64	1.67	74.01	1.36	60.19	1.08	3.09	0.04
16	78.41	1.78	69.38	1.45	56.43	1.15	2.90	0.05
17	73.80	1.89	65.30	1.54	53.11	1.22	2.72	0.05
18	69.70	2.00	61.67	1.63	50.16	1.29	2.57	0.05
19	66.03	2.11	58.43	1.72	47.52	1.36	2.43	0.05
20	62.73	2.22	55.50	1.81	45.14	1.44	2.32	0.06
21	59.74	2.33	52.86	1.90	42.99	1.51	2.21	0.06
22	57.03	2.44	50.46	2.00	41.04	1.58	2.11	0.06
23	54.54	2.55	48.27	2.09	39.25	1.65	2.02	0.07
24	52.27	2.66	46.25	2.18	37.62	1.72	1.93	0.07
25	50.18	2.78	44.40	2.27	36.12	1.79	1.85	0.07
26	48.25	2.89	42.70	2.36	34.72	1.87	1.78	0.08
27	46.47	3.00	41.12	2.45	33.44	1.94	1.71	0.08
28	44.81	3.11	39.65	2.54	32.25	2.01	1.66	0.08
29	43.26	3.22	38.28	2.63	31.13	2.08	1.60	0.08
30	41.82	3.33	37.00	2.72	30.09	2.15	1.54	0.09
31	40.47	3.44	35.81	2.81	29.12	2.23	1.49	0.09
32	39.21	3.55	34.69	2.90	28.21	2.30	1.45	0.09
33	38.02	3.66	33.64	2.99	27.36	2.37	1.41	0.10
34	36.91	3.77	32.65	3.08	26.55	2.44	1.37	0.10
35	35.85	3.89	31.72	3.17	25.80	2.51	1.33	0.10
36	34.85	4.00	30.84	3.27	25.08	2.58	1.29	0.10
37	33.91	4.11	30.00	3.36	24.40	2.66	1.25	0.11
38	33.02	4.22	29.21	3.45	23.76	2.73	1.22	0.11
39	32.16	4.33	28.47	3.54	23.15	2.80	1.19	0.11

Above values are based on maximum fiber strains of 13,000 lbs. per sq. in.; $\frac{13}{16}$″ rivet holes in both flanges deducted. Weights of girders correspond to lengths, center to center of bearings

BEAM BOX GIRDERS.

SAFE LOADS IN TONS, UNIFORMLY DISTRIBUTED.

2–20″ I Beams and 2 Plates 16″×¾″

Distance, center to center of bearings, in feet.	7¾″  2 plates 16×¾ 20″ I Beams, 80.0 lbs. per foot.			7″  2 plates, 16×¾ 20″ I Beams, 64.0 lbs. per foot.			Increase in weight of girder for 1-16″ increase in thickness of flange plates.
	Safe load uniformly distributed (including weight of girder) in tons of 2,000 lbs.	Weight of girder (including rivet heads) in tons of 2,000 lbs.	Increase in safe load for 1-16 increase in thickness of flange plates.	Safe load uniformly distributed (including weight of girder) in tons of 2,000 lbs.	Weight of girder (including rivet heads) in tons of 2,000 lbs.	Increase in safe load for 1-16 increase in thickness of flange plates.	
10	199.67	1.22	7.22	176.72	1.06	7.34	0.03
11	181.51	1.34	6.56	160.66	1.16	6.68	0.04
12	166.39	1.46	6.02	147.26	1.27	6.12	0.04
13	153.60	1.58	5.56	135.95	1.37	5.65	0.04
14	142.64	1.70	5.16	126.24	1.48	5.25	0.05
15	133.12	1.83	4.81	117.82	1.58	4.90	0.05
16	124.80	1.95	4.51	110.45	1.69	4.59	0.05
17	117.47	2.07	4.25	103.96	1.79	4.32	0.06
18	110.94	2.19	4.01	98.18	1.90	4.08	0.06
19	105.10	2.31	3.80	93.01	2.01	3.86	0.06
20	99.83	2.43	3.61	88.36	2.11	3.67	0.07
21	95.08	2.56	3.44	84.15	2.22	3.50	0.07
22	90.77	2.68	3.28	80.33	2.32	3.34	0.07
23	86.82	2.80	3.14	76.84	2.43	3.19	0.08
24	83.20	2.92	3.01	73.64	2.53	3.06	0.08
25	79.87	3.04	2.89	70.69	2.64	2.94	0.08
26	76.80	3.16	2.78	67.97	2.75	2.82	0.09
27	73.96	3.29	2.68	65.46	2.85	2.72	0.09
28	71.32	3.41	2.58	63.12	2.96	2.62	0.09
29	68.86	3.53	2.49	60.94	3.06	2.53	0.10
30	66.56	3.65	2.41	58.91	3.17	2.45	0.10
31	64.41	3.77	2.33	57.01	3.27	2.37	0.10
32	62.41	3.89	2.26	55.22	3.38	2.29	0.11
33	60.51	4.02	2.19	53.56	3.48	2.22	0.11
34	58.73	4.14	2.12	51.98	3.59	2.16	0.11
35	57.05	4.26	2.06	50.50	3.70	2.10	0.12
36	55.46	4.38	2.01	49.09	3.80	2.04	0.12
37	53.96	4.50	1.95	47.77	3.91	1.98	0.12
38	52.54	4.62	1.90	46.51	4.01	1.93	0.13
39	51.20	4.75	1.85	45.32	4.12	1.88	0.13

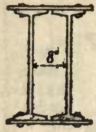
Above values are based on maximum fiber strains of 13,000 lbs. per sq. in.; $\frac{13}{16}$″ rivet holes in both flanges deducted. Weights of girders correspond to lengths, center to center of bearings.

BEAM BOX GIRDER.

SAFE LOADS IN TONS, UNIFORMLY DISTRIBUTED.

2-24″ I Beams and 2 Plates 18″×¾″

2 plates, 18×¾



24″ I Beams, 80.0 lbs. per foot.

Distance, center to center of bearings, in feet.	Safe load uniformly distributed (including weight of girder) in tons of 2,000 lbs.	Weight of girder (including rivet heads) in tons of 2,000 lbs.	Increase in safe load for $\frac{1}{16}$″ increase in thickness of flange plate.	Increase in weight of girder for $\frac{1}{16}$″ increase in thickness of flange plates.
14	182.64	1.78	7.19	0.05
15	170.46	1.91	6.71	0.06
16	159.81	2.03	6.29	0.06
17	150.40	2.16	5.92	0.06
18	142.05	2.29	5.59	0.07
19	134.57	2.41	5.30	0.07
20	127.84	2.54	5.03	0.08
21	121.76	2.67	4.79	0.08
22	116.22	2.79	4.57	0.08
23	111.17	2.92	4.38	0.09
24	106.54	3.05	4.19	0.09
25	102.27	3.18	4.03	0.09
26	98.34	3.30	3.87	0.10
27	94.70	3.43	3.73	0.10
28	91.32	3.56	3.59	0.11
29	88.17	3.68	3.47	0.11
30	85.23	3.81	3.35	0.11
31	82.48	3.94	3.25	0.12
32	79.90	4.06	3.15	0.12
33	77.48	4.19	3.05	0.12
34	75.20	4.32	2.96	0.13
35	73.05	4.45	2.88	0.13
36	71.03	4.57	2.80	0.14
37	69.11	4.70	2.72	0.14
38	67.29	4.83	2.65	0.14
39	65.56	4.95	2.58	0.15
40	63.92	5.08	2.52	0.15
41	62.36	5.20	2.45	0.16
42	60.88	5.33	2.40	0.16
43	59.46	5.46	2.34	0.16
44	58.11	5.59	2.29	0.17
45	56.82	5.73	2.25	0.17

Above values are based on maximum fiber strains of 13,000 lbs. per sq. in.; $\frac{13}{16}$″ rivet holes in both flanges deducted. Weights of girders correspond to lengths, center to center of bearings.

EXPLANATION OF TABLES ON RIVETED PLATE GIRDERS.

Riveted girders are used in cases where rolled beams are insufficient to carry the load. On page 57 of the lithograph plates will be found illustrations of various forms of riveted girders. The sections with single webs are more economical than those with double webs box girders, but the latter are stiffer laterally, and should always be used where great length of span requires a wide-top flange. If the girder is not held in position sideways, the proportion of length of span to width of flange should not exceed twenty, without making provision for such increase by an addition of metal in the compression flange beyond that required by the table.

The web of the girder must be made of such thickness that there will be no tendency to buckle, and that the vertical shearing strain per square inch will not exceed 10,000 pounds. This shearing stress is greatest near the supports and is obtained by dividing half the load upon the girder (provided the load is symmetrically applied) by the web section. The first condition (security against buckling) is attained when this shearing strain does not exceed $\dfrac{11000}{1+\dfrac{d^2}{3000\,t^2}}$ in which d represents the depth of web in clear of flange of girder, and t the thickness of one web plate in inches. Ordinarily this formula gives a lower strain per square inch than 10,000 pounds, so that both conditions are usually attained when the first is. Instead of increasing the thickness of the web, it may be stiffened by means of vertical angles riveted to it at proper intervals. These latter should always be less than the depth of the girder, at least near the ends, but toward the middle of the girder the stiffeners may be placed further apart or entirely omitted. Stiffeners should always be used at or near the supports, and at any other point where there is a concentration of heavy loads. The duty of these stiffeners in such cases is twofold: first, to prevent buckling of the web; second, to transmit the shear to the web by means of the abutting areas and the rivets, both of which must be sufficient for the purpose.

The rivets generally should be ¾″ and the spacing in flanges ought not to exceed six inches, and should be closer for heavy flanges; but in all cases it should be close at the ends, say three inches for a distance equal to the depth of the girder. Where loads are great, especial calculation for rivet spacing should be made, allowing 9,000 pounds per square inch for shearing and 18,000 pounds per square inch for bearing.

The unsupported width of flange plates, subjected to compres-

sion, should not exceed 32 times their thickness, nor should the flange plates extend beyond the outer line of rivets more than five inches nor more than eight times their thickness.

The term "flange," as applied to the riveted girders, embraces all the metal in top or bottom of girder exclusive of web plate; or, in the case of a rolled beam or channel with top and bottom plates, all the metal exclusive of that part of the web between fillets.

Girders intended to carry plastering should be limited in depth from out to out to $\frac{1}{20}$ of the span length ($\frac{5}{8}''$ per foot); otherwise the deflection is liable to cause the plastering to crack.

The following pages, Nos. 120 to 123, inclusive, furnish a ready means for determining the sections of plate or box girders necessary to carry specified loads for spans varying from 20 to 40 feet, center to center of bearings.

The "Safe Loads" are given for the sections shown, and in columns headed "Increase in Safe Load" is given the increase in safe load for each $\frac{1}{16}''$ increase in thickness of flange plates. The flange plates may be altered in width and thickness, provided the section remains the same as that required in the table and the conditions in regard to unsupported width be fulfilled.

EXAMPLE OF APPLICATION OF TABLE.

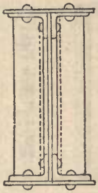
A 30″ box girder is to carry a load of 80 tons over a clear span of 30 feet. What section of girder is required? The span from center to center of bearings we will assume to be 31 feet.

In the table, page 122, the safe load for this span and for the girder shown is found to be 62.96 tons including weight of girder, which latter, according to the table, may be assumed at about 3.5 tons. The total load to be carried is, therefore, 83.5 tons. The increase in safe load for $\frac{1}{16}''$ increase in thickness of flange plate given in the table is 3.70 tons. The thickness of the flange plate is then obtained as follows: 83.5 tons − 62.96 tons = 20.54 tons. This ÷ 3.70 tons is very nearly 6. Each flange plate, therefore, must be increased by $\frac{6}{16}''$, making a total thickness of flange plate of $\frac{3}{4}''$.

The section of the girder is then composed of two $30'' \times \frac{1}{2}''$ web plates, two $16'' \times \frac{3}{4}''$ flange plates (which could be made $18'' \times \frac{11}{16}''$ or $20'' \times \frac{5}{8}''$, etc.—see previous note), and four $3\frac{1}{2}'' \times 3\frac{1}{2}'' \times \frac{1}{2}''$ flange angles. The shear in one web is $\frac{83.5 \times 2000}{2 \times 2 \times 30 \times \frac{1}{2}}$ or 2785 pounds per square inch, which is also safe against buckling, since it is less than $\dfrac{11000}{1 + \dfrac{d^2}{3000\,t^2}}$ which, in this case, is 5,000 pounds.

PLATE GIRDERS.

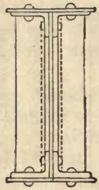
SAFE LOADS IN TONS, UNIFORMLY DISTRIBUTED.

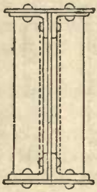
Distance Center to Center of Bearings, in Feet.	 30″ x ½″ Web Plate. 12″ x ⅜″ Flange Plates. 5″ x 3½″ x ½″ Angles.				 33″ x ½″ Web Plate. 12″ x ⅜″ Flange Plates. 5″ x 3½″ x ½″ Angles.			
	Safe Load, including weight of girder.	Weight of girder.	Increase in safe load for $\frac{1}{16}''$ increase in thickness of flange plates.	Increase in weight of girder for $\frac{1}{16}''$ increase in thickness of flange plates.	Safe load, including weight of girder.	Weight of girder.	Increase in safe load for $\frac{1}{16}''$ increase in thickness of flange plates.	Increase in weight of girder for $\frac{1}{16}''$ increase in thickness of flange plates.
20	81.18	1.62	4.00	.05	91.71	1.70	4.40	.05
21	77.32	1.69	3.80	.05	87.34	1.77	4.20	.05
22	73.80	1.76	3.63	.06	83.37	1.84	4.00	.06
23	70.60	1.86	3.47	.06	79.74	1.95	3.83	.06
24	67.66	1.93	3.32	.06	76.42	2.02	3.67	.06
25	64.95	2.01	3.19	.06	73.36	2.09	3.52	.06
26	62.45	2.07	3.07	.07	70.54	2.17	3.39	.07
27	60.14	2.14	2.96	.07	67.93	2.24	3.26	.07
28	57.99	2.21	2.85	.07	65.50	2.31	3.15	.07
29	55.99	2.31	2.75	.07	63.25	2.42	3.03	.07
30	54.12	2.38	2.66	.08	61.14	2.49	2.94	.08
31	52.38	2.45	2.57	.08	59.16	2.56	2.85	.08
32	50.74	2.52	2.50	.08	57.32	2.64	2.75	.08
33	49.20	2.59	2.42	.08	55.58	2.71	2.67	.08
34	47.76	2.66	2.34	.09	53.94	2.78	2.59	.09
35	46.39	2.73	2.28	.09	52.40	2.85	2.52	.09
36	45.10	2.83	2.22	.09	50.95	2.96	2.45	.09
37	43.88	2.90	2.16	.09	49.57	3.03	2.38	.09
38	42.73	2.97	2.10	.10	48.27	3.11	2.31	.10
39	41.63	3.04	2.05	.10	47.03	3.18	2.25	.10
40	40.59	3.11	2.00	.10	45.85	3.25	2.21	.10

The above values are founded on the moments of inertia of the sections using a maximum fiber strain of 13,000 lbs. per square inch; $\frac{13}{16}''$ rivet holes in both flanges deducted. Weights of girders correspond to lengths, center to center of bearings and include rivet heads, stiffeners and fillers.

PLATE GIRDERS.

SAFE LOADS IN TONS, UNIFORMLY DISTRIBUTED.



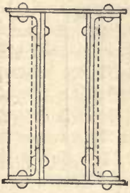
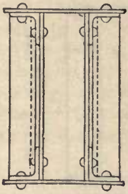


Distance Center to Center of Bearings, in Feet.	36″x1/2″ Web Plate. 12″x3/8″ Flange Plates. 5″x3 1/2″x1/2″ Angles.				42″x5/8″ Web Plate. 14″x3/8″ Flange Plates. 6″x6″x3/8″ Angles.			
	Safe Load, including weight of girder.	Weight of girder.	Increase in safe load for 1/16″ increase in thickness of flange plates.	Increase in weight of girder for 1/16″ increase in thickness of flange plates.	Safe load, including weight of girder.	Weight of girder.	Increase in safe load for 1/16″ increase in thickness of flange plates.	Increase in weight of girder for 1/16″ increase in thickness of flange plates.
20	102.57	1.77	4.80	.05	152.54	2.72	6.71	.06
21	97.67	1.85	4.58	.05	145.28	2.84	6.39	.06
22	93.23	1.92	4.37	.06	138.68	2.95	6.09	.07
23	89.18	2.04	4.18	.06	132.65	3.12	5.83	.07
24	85.46	2.17	4.01	.06	127.12	3.24	5.58	.07
25	82.04	2.19	3.85	.06	122.04	3.36	5.36	.07
26	78.88	2.26	3.70	.07	117.34	3.48	5.16	.08
27	75.96	2.34	3.56	.07	113.00	3.59	4.97	.08
28	73.26	2.41	3.43	.07	108.97	3.71	4.78	.08
29	70.73	2.53	3.31	.07	105.20	3.88	4.63	.09
30	68.37	2.60	3.21	.08	101.70	4.00	4.48	.09
31	66.16	2.68	3.10	.08	98.42	4.12	4.32	.09
32	64.10	2.75	3.00	.08	95.34	4.23	4.20	.10
33	62.16	2.82	2.91	.08	92.45	4.35	4.07	.10
34	60.33	2.89	2.83	.09	89.74	4.47	3.94	.10
35	58.60	2.98	2.75	.09	87.17	4.59	3.83	.10
36	56.98	3.09	2.66	.09	84.74	4.76	3.73	.11
37	55.44	3.16	2.59	.09	82.46	4.87	3.62	.11
38	53.98	3.24	2.52	.10	80.29	4.99	3.53	.11
39	52.59	3.31	2.47	.10	78.23	5.11	3.43	.12
40	51.26	3.39	2.40	.10	76.27	5.23	3.35	.12

The above values are founded on the moments of inertia of the sections using a maximum fiber strain of 13,000 lbs. per square inch; 13/16″ rivet holes in both flanges deducted. Weights of girders correspond to lengths, center to center of bearings and include rivet heads, stiffeners and fillers.

BOX GIRDERS.

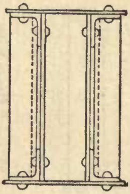
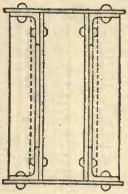
SAFE LOADS IN TONS, UNIFORMLY DISTRIBUTED.

Distance Center to Center of Bearings, in Feet.	 30″x½″ Web Plates. 16″x⅜″ Flange Plates. 3½″x3½″x½″ Angles.				 33″x½″ Web Plates. 20″x$\frac{7}{16}$″ Flange Plates. 3½″x3½″x½″ Angles.			
	Safe Load, including weight of girder.	Weight of girder.	Increase in safe load for $\frac{1}{16}$″ increase in thickness of flange plates.	Increase in weight of girder for $\frac{1}{16}$″ increase in thickness of flange plates.	Safe load, including weight of girder.	Weight of girder.	Increase in safe load for $\frac{1}{16}$″ increase in thickness of flange plates.	Increase in weight of girder for $\frac{1}{16}$″ increase in thickness of flange plates.
20	97.59	2.13	5.73	.07	130.2	2.44	7.95	.09
21	92.94	2.23	5.46	.07	124.0	2.55	7.58	.09
22	88.72	2.32	5.20	.08	118.3	2.66	7.22	.09
23	84.86	2.45	4.98	.08	113.2	2.80	6.90	.10
24	81.32	2.54	4.78	.08	108.5	2.91	6.62	.10
25	78.07	2.64	4.59	.09	104.1	3.03	6.35	.11
26	75.07	2.74	4.41	.09	100.1	3.14	6.12	.11
27	72.29	2.83	4.25	.09	96.4	3.25	5.89	.12
28	69.70	2.93	4.10	.10	93.0	3.36	5.67	.12
29	67.30	3.06	3.96	.10	89.8	3.50	5.48	.12
30	65.06	3.16	3.82	.10	86.8	3.61	5.29	.13
31	62.96	3.25	3.70	.11	84.0	3.72	5.13	.13
32	61.00	3.35	3.58	.11	81.4	3.83	4.97	.14
33	59.14	3.50	3.48	.11	78.9	3.95	4.82	.14
34	57.40	3.54	3.38	.12	76.6	4.06	4.67	.14
35	55.76	3.64	3.28	.12	74.4	4.17	4.53	.15
36	54.22	3.76	3.18	.12	72.3	4.31	4.41	.15
37	52.75	3.86	3.09	.13	70.4	4.41	4.30	.16
38	51.36	3.95	3.02	.13	68.5	4.53	4.18	.16
39	50.04	4.05	2.94	.13	66.7	4.65	4.07	.17
40	48.80	4.15	2.86	.14	65.1	4.76	3.97	.17

The above values are founded on the moments of inertia of the sections using a maximum fiber strain of 13,000 lbs. per square inch; $\frac{13}{16}$″ rivet holes in both flanges deducted. Weights of girders correspond to lengths, center to center of bearings and include rivet heads, stiffeners and fillers.

BOX GIRDERS.

SAFE LOADS IN TONS, UNIFORMLY DISTRIBUTED.

Distance Center to Center of Bearings, in Feet.	 36″×½″ Web Plate. 24″×$\frac{9}{16}$″ Flange Plates. 4″×3½″×½″ Angles.				 42″×½″ Web Plate. 30″×$\frac{11}{16}$″ Flange Plates. 5″×4″×½″ Angles.			
	Safe Load, including weight of girder.	Weight of girder.	Increase in safe load for $\frac{1}{16}$″ increase in thickness of flange plates.	Increase in weight of girder for $\frac{1}{16}$″ increase in thickness of flange plates.	Safe load, including weight of girder.	Weight of girder.	Increase in safe load for $\frac{1}{16}$″ increase in thickness of flange plates.	Increase in weight of girder for $\frac{1}{16}$″ increase in thickness of flange plates.
20	184.9	2.92	10.59	.10	288.5	3.78	15.80	.13
21	176.2	3.06	10.10	.11	274.8	3.95	15.05	.13
22	168.2	3.19	9.64	.11	262.3	4.13	14.37	.14
23	160.8	3.36	9.22	.12	251.0	4.34	13.74	.15
24	154.2	3.49	8.84	.12	240.5	4.52	13.17	.15
25	148.0	3.63	8.48	.13	230.9	4.69	12.64	.16
26	142.4	3.76	8.18	.13	222.0	4.87	12.16	.17
27	137.0	3.89	7.85	.14	213.8	5.04	11.70	.17
28	132.1	4.03	7.57	.14	206.2	5.21	11.29	.18
29	127.6	4.15	7.31	.15	199.0	5.43	10.91	.19
30	123.3	4.33	7.06	.15	192.4	5.61	10.54	.19
31	119.3	4.45	6.83	.16	186.2	5.78	10.21	.20
32	115.6	4.60	6.63	.16	180.3	5.95	9.88	.20
33	112.1	4.74	6.43	.17	174.9	6.12	9.58	.21
34	108.8	4.87	6.24	.17	169.8	6.29	9.30	.22
35	105.7	5.00	6.06	.18	164.9	6.47	9.03	.22
36	102.8	5.17	5.90	.18	160.3	6.69	8.78	.23
37	100.0	5.31	5.74	.19	156.0	6.86	8.54	.24
38	97.4	5.44	5.58	.19	151.9	6.94	8.32	.24
39	94.9	5.58	5.44	.20	148.0	7.20	8.11	.25
40	92.5	5.71	5.30	.20	144.3	7.38	7.91	.26

The above values are founded on the moments of inertia of the sections using a maximum fiber strain of 13,000 lbs. per square inch; $\frac{13}{16}$″ rivet holes in both flanges deducted. Weights of girders correspond to lengths, center to center of bearings and include rivet heads, stiffeners and fillers.

I-BEAMS AS USED IN FOUNDATIONS.

In designing the foundations of walls and piers of buildings, when they rest upon a yielding stratum, proper provision must be made for the uniform distribution of the weight. In case the walls are of different thicknesses and heights, the widths of the foundations must be proportioned according to the different loads resulting therefrom, so that the bearing per unit of ground-area will be equal and a uniform settlement of the completed structure is ensured.

The introduction of timber beams as a means of obtaining wider bearing surfaces at the base, is a practice to be strongly condemned, unless the wood is in a position to remain continually moist. Where this is not the case, the timber will soon rot away, thereby giving rise to an unequal settlement of the walls, which is very injurious, if not destructive, to the masonry.

Rails, imbedded in concrete, are not open to this objection. They offer, however, comparatively little resistance to deflection, and for this reason, if allowed to project beyond the masonry to any considerable length, the concrete filling is liable to crack, and thus the strength of the foundation becomes impaired.

I-beams, more recently used for this purpose, are found to be superior in every respect. A greater depth can be adopted, the deflection thus reduced to a minimum and a sufficient saving effected to more than compensate for their additional cost per pound.

The foundation should be prepared (see illustration p. 126) by first laying a bed of concrete to a depth of from 4 to 12 inches and then placing upon this a row of I-beams at right angles to the face of the wall. In the case of heavy piers, the beams may be crossed in two directions. Their distances apart, from center to center, may vary from 9 to 24 inches according to circumstances, *i. e.*, length of their projection beyond the masonry, thickness of concrete, estimated pressure per square foot, etc. They should be placed at least far enough apart to permit the introduction of the concrete filling and its proper tamping between the beams. Unless the concrete is of unusual thickness, it will not be advisable to exceed 20″ spacing, since otherwise the concrete may not be of sufficient strength to properly transmit the npward pressure to the beams. The most useful application of this method of founding, is in localities where a thin and comparatively compact stratum overlies another of a more yielding nature. By using I-beams in such cases, the requisite spread at the base may be obtained without either penetrating the firm upper stratum or carrying the footing-courses to such a height as to encroach unduly upon the basement-room.

METHOD OF CALCULATION.

Let L=Weight of wall per lineal foot, in tons.

and b=Assumed bearing capacity of ground, per square foot, (usually from 1 to 3 tons.)

Then $\frac{L}{b}$=W=Required width of foundation, in feet.

w=Width of lowest course of footing-stones.

p=Projection of beams beyond masonry, in feet.

s=Spacing of beams center to center, in feet.

Evidently the size of beams required will depend upon their strength as cantilevers of a length "p," sustaining the upward reaction, which may be regarded as a uniformly distributed load.

Thus p b=uniformly distributed load (in tons) on cantilevers, per lineal foot of wall,

and p b s=uniform load in tons, on each beam.

The table on the following page gives the safe lengths "p" for the various sizes and weights of beams, for s=1 foot and "b" ranging from 1 to 5 tons per square foot. For other values of "s" say 15″, *i. e.*, 1¼′, the table may be used by simply considering "b" increased in the same ratio as "s" (see example below). As regards the weight of beams, it is advantageous to assign to "s" as great a value as is warranted by the other considerations which obtain.

EXAMPLE SHOWING APPLICATION OF TABLE.

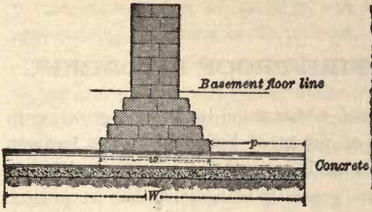
The weight of a brick wall, together with the load it must support, is 40 tons per lineal foot. The width of the lowest footing-course of masonry is 6 feet. Allowing a pressure of 2 tons per square foot on the foundation, what size and length of I-beams 18″ center to center will be required?

Answer: L=40 b=2 w=6 s=1½.

Therefore W=40÷2=20 feet, the required length of beams. The projection "p"=½ (20–6)=7 feet.

In order to apply the table (calculated for s=1′), we must consider "b" increased in the same ratio as "s," *i. e.*, b=2× 1½=3 tons.

In the column for 3 tons, we find the length 7 feet to agree with 20″ I-beams 64.0 lbs. per foot.



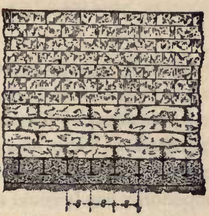


TABLE GIVING SAFE LENGTHS OF PROJECTIONS "p" IN FEET, (SEE ILLUSTRATION,) FOR "s"=1 FOOT AND VALUES OF "b" RANGING FROM 1 TO 5 TONS.

Depth of beam, in.	Weight per foot.	b (TONS PER SQUARE FOOT.)										
		1	1¼	1½	2	2¼	2½	3	3½	4	4½	5
20	80	14.0	12.5	11.5	10.0	9.0	9.0	8.0	7.5	7.0	6.5	6.0
20	64	12.5	11.0	10.0	8.5	8.0	8.0	7.0	6.5	6.0	6.0	5.5
15	80	12.0	10.5	9.5	8.5	8.0	7.5	7.0	6.5	6.0	5.5	5.0
15	60	10.5	9.5	8.5	7.5	7.0	6.5	6.0	5.5	5.5	5.0	5.0
15	50	9.5	8.5	8.0	7.0	6.5	6.0	5.5	5.0	5.0	4.5	4.5
15	41	8.5	8.0	7.0	6.0	6.0	5.5	5.0	4.5	4.5	4.0	4.0
12	40	8.0	7.0	6.5	5.5	5.5	5.0	4.5	4.0	4.0	3.5	3.5
12	32	7.0	6,5	5.5	5.0	4.5	4.5	4.0	4.0	3.5	3.5	3.0
10	33	6.5	6.0	5.5	4.5	4.5	4.0	4.0	3.5	3.5	3.0	3.0
10	25	5.5	5.0	4.5	4.0	4.0	3.5	3.5	3.0	3.0	2.5	2.5
9	21	5.0	4.5	4.0	3.5	3.5	3.0	3.0	2.5	2.5	2.5	2.0
8	18	4.5	4.0	3.5	3.0	3.0	3.0	2.5	2.5	2.0	2.0	2.0
7	15	4.0	3.5	3.0	2.5	2.5	2.5	2.0	2.0	2.0	2.0	1.5
6	13	3.0	3.0	2.5	2.5	2.0	2.0	2.0	1.5	1.5	1.5	1.5
5	10	2.5	2.5	2.0	2.0	1.5	1.5	1.5	1.5	1.5	. .	. .
4	7	2.0	2.0	1.5	1.5	1.5	1.5	. .	. .	. .	. .	. .

Values given based on extreme fiber strains of 16,000 lbs. per square inch.

COLUMNS IN FIRE-PROOF BUILDINGS.

The subject of fire-proof construction is steadily growing in importance. The need of fire-proof buildings in the business centers of our great cities has been well demonstrated, and their superiority has become so generally recognized, that at present but few structures of any size or importance are designed which are not more or less of this type. This change has been facilitated in no small measure by a number of signal improvements made of late in the art of fire-proof construction, ensuring not only a higher degree of efficiency, but a considerable reduction in cost, compared with methods formerly practiced.

The old style of solid brick arch, once so prevalent in floor-construction, has been almost wholly supplanted by the more modern forms of hollow tile and terra cotta arches. The important advantages of the latter have been already pointed out in these pages. Roofs, ceilings and partition walls are now also largely constructed of these light refractory materials.

The substitution of steel for iron in beams may be cited as a more recent though hardly less radical improvement in this direction, and, simultaneously, the introduction by this firm of new patterns for its steel beams. These patterns are of more convenient shape and much more economical of material than the old forms.

Another change which is gradually taking place is the substitution of steel for cast iron in the composition of columns. Cast iron is a material, so uncertain in character, that its use has long since been abandoned in bridge construction. In buildings the loads are generally quiescent, and the liability to sudden shocks is more remote than in bridges; yet, on the other hand, the columns seldom receive their loads as favorably as in bridges; in most cases there exists considerable eccentricity, that is, the loads on one side of the column are heavier than those on the other side, and the bending strains arising therefrom increase the strains from direct compression materially.

The following are some of the contingencies which may arise

in the manufacture of castings, and which preclude anything approaching uniformity in the product.

In the case of hollow cast iron columns, while the metal is yet in a molten state, the buoyancy of the central core tends to cause it to rise, thereby reducing the thickness of the metal above and increasing the same below. When columns are of such a length as to make it necessary to pour the metal into the mould from both ends, it sometimes occurs that the iron becomes too much chilled on the surface to properly mix and unite, thus creating a weak seam at the very point where the greatest strength will be needed. The presence of confined air, producing "blow holes" and "honey-comb," and the collection of impurities at the bottom of the mould may be further mentioned as frequent sources of weakness in cast iron.

The most critical condition, however, is that due to the unequal contraction of the metal during the process of cooling, thereby giving rise to initial strains, at times of sufficient force to produce rupture in the column or in its lugs on the slightest provocation. In many cases, the trouble can be ascribed to faulty designing or carelessness in the execution of the work, yet even under favorable conditions, it is so difficult to secure equal radiation from the moulds in all directions that castings, entirely exempt from inherent shrinkage strains, are probably seldom produced.

As a protection against these contingencies, resort must be had either to the crude and uncertain expedient of a high safety factor, not less than eight or ten, or a material, such as rolled steel, must be adopted, of a more uniform and reliable character than cast iron.

STEEL COLUMNS fail either by deflecting bodily out of a straight line, or by the buckling of the metal between rivets or other points of support. Both actions may take place at the same time, but if the latter occurs alone, it may be an indication that the rivet spacing or the thickness of the metal is insufficient.

The rule has been deduced from actual experiments upon wrought iron columns, that the distance between centers of rivets should not exceed, in the line of strain sixteen times the thickness of metal of the parts joined, and that the distance between

rivets or other points of support, at right angles to the line of strain, should not exceed thirty-two times the thickness of the metal.

On page 53 sections are shown of some of the most common forms of built columns. Figs. 6, 13, 15 and 16, belong to the type known as Closed Columns. As it is impracticable to repaint the inner surfaces of such columns, they should preferably be used only for interior work, where the changes in temperature are not considerable, and the air is comparatively dry. In places exposed to the extremes of temperature and unprotected from the rain, the paint on the inner surface of the column will, sooner or later, cease to be a protection, corrosion will set in, and, once begun, will continue as long as there is unoxidized metal left in the column.

The remaining figures on the same page represent types of columns with open sections, which readily admit of repainting, and are therefore suitable for out-door work.

Of these, Fig. 14, known as Z-bar column, is believed to offer advantages superior to those of any other steel or wrought iron column in the market.

Its claims for superiority are based mainly on the following qualities:

1st. Economy of Manufacture.—Only two rows of rivets are required, while four or more are used for any other column of an equal sectional area.

2d. High Ultimate Resistance to Compression.—For discussion on this point see pages 131 to 133, inclusive.

3d. Great Adaptability for Effecting Connections with I-beams, and Reducing Eccentricity of Loading.—When used in buildings, for supporting single floor beams or double beam girders, these qualities are of the greatest importance. Complete details of these connections are shown on pages 55 and 56.

4th. Favorable Form for Inspection and Repainting.—This is a very desirable feature when used for out-door work. In buildings, as a rule, the columns are permanently encased in a fire-proofing composition.

When unusually heavy loads must be provided for, as in the case of columns for the lower stories of very high buildings, the standard sections of Z-bar columns may be reinforced to the required strength by using either a double central web plate or by the addition of outside cover plates, or, if need be, both, forming thus a closed or box column. Standard cast bases are shown in Figs. 4, 5 and 6, and standard built bases in Figs. 7 and 8, page 54.

The standard connections for double I-beam girders and single floor beams to Z-bar columns, detailed on pages 55 and 56, were designed to fairly cover the range of ordinary practice. When the maximum loads, in tons, indicated for each case, are exceeded, the connections may be correspondingly strengthened by simply using longer vertical angles for the brackets and increasing the number of rivets. In proportioning these connections, the shearing strain on rivets was assumed of a maximum intensity of 10,000 lbs. per square inch.

On page 54, Figs. 1, 2 and 3, are shown different forms of fireproofing for Z-bar columns, giving the latter a cylindrical or a prismatic finish with rounded corners, as may be preferred. The air space between the tiling and the metal adds to the protection of the latter in the event of fire. The recesses in the columns may be used to good advantage in buildings for conducting water and gas pipes, electric wires, etc.

Complete tables of dimensions and safe loads in tons for standard Z-bar columns of different lengths are given on pages 135 to 148, inclusive.

COLUMNS AND STRUTS.

EXPLANATION OF TABLES, PAGES 135 TO 154, INCLUSIVE.

The tables on Safe Loads for Z-bar Columns are applicable to lengths up to 50′ for the larger, and up to 40′ for the smaller columns. Complete dimensions are given opposite the tables of safe loads. These tables are compiled on the basis of an allowable strain per square inch of 12,000 pounds (factor of safety 4), for lengths of 90 radii and under, and an allowable strain, deduced from the formula $17,100-57\frac{l}{r}$, for lengths greater than this limit.

No tests have as yet been made on full sized *steel* Z-bar columns, and the above deductions are based on a series of experiments made on full sized *iron* Z-bar columns. For a detailed report of these tests, see Trans. Am. Soc. C. E., paper by C. L. Strobel on Z-bar Columns, April, 1888. A condensed summary of the results of these compression tests is given below :—

Section of Columns: 4 Z-bars, $2\frac{1}{4}'' \times 3'' \times 2\frac{1}{4}''$—(latticed.)
Radius of Gyration—(Lattice bars not considered)=2.05″

Length of Column.	Sectional Area. Square inches.	Ultim. Strength by actual tests: Pounds per square inch.	Ratio of length to least radius of gyration.	Ultim. Strength by formula, (Rankine-Gordon) $\frac{36000}{1+\frac{l^2}{36000\,r^2}}$	Ultimate Strength by formula: $46000-125\frac{l}{r}$
10′—11¼″	9.435	36800	64	32300	
" — "	9.984	34600	"	"	
15′— 0″	9.480	34600	88	29600	35000
" — "	9.280	36600	"	"	"
19′— 0¾″	9.241	33800	112	26700	32200
" — "	10.104	33700	"	"	"
22′— 0″	9.286	30700	129	24600	29900
" — "	9.286	29500	"	"	"
" — "	9.286	30700	"	"	"
25′— 0″	9.156	28100	146	22600	27750
" — "	9.456	28000	"	"	"
" — "	9.516	28400	"	"	"
28′— 0″	9.375	27700	164	20600	25500
" — "	9.643	28000	"	"	"
" — "	9.375	27600	"	"	"

From these tests the ultimate stress per square inch for *iron* Z-bar columns whose lengths were equal to or less than 90 radii, was found to be 35,000 lbs.; and for columns, whose lengths exceeded this limit, this stress conformed very closely to that deduced from the formula $46,000-125\frac{l}{r}$.

It has been customary to allow 8,000 pounds per square inch in compression for bridge members of short length, which corresponds to a factor of safety of $\frac{35000}{8000}=4.375$, when taken with reference to the ultimate strength.

Dividing the constants in the above formula by 4.375, we obtain nearly $10,600—28.5\frac{l}{r}$. For convenience and as providing additional security for long members, it was thought advisable to substitute 30 for 28.5 as the second constant, thus reducing the formula to the shape in which it appears in the tables.

It is to be noted that the allowable stresses were assumed at 8,000 and 10,000 pounds per square inch respectively for lengths of 90 radii and under. The above mentioned tests on Iron Z-bar columns, as well as former tests upon columns of other types all warrant the conclusion that to this limit at least the ultimate strength is practically constant irrespective of length, though varying for different types of columns.

Further experiments made to determine the relative strength of steel and iron struts indicate, that for lengths up to 90 radii of gyration, the ultimate strength of steel is about 20 per cent. higher than for iron. Beyond this point the excessive strength diminishes, until it becomes zero at about 200 radii. After passing this limit the compressive resistance of steel and iron seems to become practically equal.

From these experiments the final results are obtained; for steel Z-bar columns, of lengths of 90 radii and under, 12,000 lbs. per square inch is taken as the allowable stress, being 20 per cent. in excess of that for iron (factor of safety 4). The formula $17,100—57\frac{l}{r}$, used for columns of greater lengths gives results 20 per cent. higher than the corresponding values for iron for lengths of 90 radii, and from this point the ratio of excess will be found to decrease after the manner of the above mentioned experimental resul s.

The steel referred to here is what is known as "mild" steel having an ultimate strength of about 60,000 pounds per square inch and containing a comparatively low percentage of carbon.

The values given in tables on steel Z-bar columns should be used only for cases in which the loads are for the most part statical, and equal, or very nearly so, on opposite sides of the column. When there is much eccentricity of loading, or the loads are subject to sudden changes, the tabulated values must be reduced according to circumstances.

The weights included in the headings of the tables refer to the weight per foot of the entire section, exclusive of rivet heads. When ¾″ rivets are used about ¼ lb. for each rivet should be added to obtain the gross weight.

The table on the "Ultimate Strength of Wrought Iron Columns" gives the strain per square inch of section at which columns will fail, for various proportions of length, in feet, to least radius of gyration, in inches. This table should be used for columns and struts which are not cylindrical.

If the column or strut is a single rolled beam, channel or other shape, the radius of gyration will be found in the foregoing tables on the "Properties of Carnegie Shapes."

If the column is composed of two channels latticed, the channels are usually placed far enough apart so that the column will be weakest in the direction of the web, i. e., with neutral axis at right angles to the web, for which case the radius of gyration of the column is the same as that of the single channel. But if the radius of gyration is wanted for the neutral axis through the center of section parallel with web, it can readily be found, as the distance between the center of gravity of channel and center of section may be found with the aid of column 15 in table on the "Properties of Carnegie Channel Bars."

If two channels are connected by means of two plates, instead of lattice bars, as shown by Fig. 11 on page 53, it is necessary to obtain first the moment of inertia of the section whence the radius of gyration is found as the square root of the quotient of the moment of inertia divided by the area of the section. This moment of inertia, for a neutral axis, through center of section perpendicular to the plates, is equal to the cube of the width of the plate, multiplied by $\frac{1}{12}$ of the thickness of the two plates added, plus the combined area of the two channels multiplied by the square of the distance from their centers of gravity to the neutral axis. For a neutral axis in a direction parallel to the plates, it is equal to the moments of inertia of the channels as found in the tables increased by the area of the two plates multiplied by the square of the distance between the center of the plate and the center of the section.

A common form of column or strut, to be recommended for comparatively light loads is that formed simply of two angles back to back or four angles united either with a single course of lattice bars or a central web plate, as in Fig. 1, page 53.

The radii of gyration for such struts are tabulated on pages 150, 151 and 152. They are given for the neutral axis parallel to either flange and for all sizes of Carnegie Angle Bars. In cases where four angles are used, the two pairs should be spaced

far enough apart to make the column weakest about a neutral axis parallel to the central web or latticing. The radius of gyration will then be the same as that given in the tables for a single pair of angles, since the moment of inertia of the web plate about such an axis is so small that it may be disregarded entirely.

The table on "Ultimate Strength of Hollow Cast Iron Columns" and that on "Safe Loads on Hollow Cylindrical Cast Iron Columns" was computed by Gordon's formula and covers a range of lengths that will seldom be exceeded in practice.

A column is *square bearing* when it has square ends which butt against or are firmly connected with an immovable surface, such as the floor of a building; it is *pin and square bearing* when one end only is square bearing and the other presses against a close-fitting pin, and it is *pin bearing* when both ends are thus pin-jointed, with the axis of the pins in parallel directions (for example, the posts in pin-connected bridges).

EXAMPLES OF APPLICATION OF TABLES.

I. What size of Z-bar column 26 feet long, with square bearing ends, will be required to carry a load of 200 tons, using a safety factor of 4?

From the tables on steel Z-bar columns, it will be seen that for the length given, a 12″ column weighing 118.5 lbs. per foot will carry safely a load of 209.1 tons or 6.6 tons in excess of that required.

II. A strut 16 feet long, to be fixed rigidly at both ends, is needed for supporting a load of 80,000 lbs. It is to be composed of two pairs of angles, united with a single line of ¼″ lattice bars along the central plane. What weight of angles will be required with a safety factor of 5?

Answer: We will assume 4—3″×4″ angles and determine the thickness of metal required. The angles must be spread ½″ in order to admit the latticing. From the table on page 152, we find the radius of gyration of a pair of $3'' \times 4'' \times \frac{5}{16}''$ angles with the 3″ legs parallel and ½″ apart to be 1.97″. Hence the value of $\frac{l}{r} = \frac{16}{1.97} = 8.1$, for which the ultimate strength, as the table on page 149=31,680 lbs.

The allowable strain per square inch with a safety factor of 5 will therefore be 31,680÷5=6,340 lbs., and the area of the required cross-section 80,000÷6,340=12.62 square inches, or 3.16 square inches for each angle. Hence the weight per foot of each angle will be 3.16÷0.3=10 5 lbs. This weight will be found to agree with a thickness of ½ inch for a 4″×3″ angle.

SAFE LOADS IN TONS OF 2,000 LBS.

Z-BAR COLUMNS.

SQUARE ENDS.

Allowed strains per square inch; safety factor 4: $\begin{cases} \text{12,000 lbs., for lengths of 90 radii or under} \\ 17{,}100-57\frac{l}{r}, \text{ for lengths over 90 radii.} \end{cases}$

6″ Z-BAR COLUMNS.

Section: 4 Z-Bars 3″ deep and 1 Web Plate 5¾″×thickness of Z-Bars.

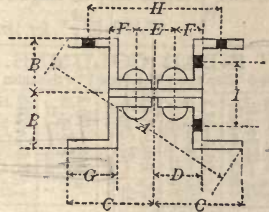
Length of Column, in Feet.	¼ Metal=31.7 lbs.=9.31 sq. in. r (min.)=1.86.	$\frac{5}{16}$ Metal=39.8 lbs.=11.7 sq. in. r (min.)=1.90.	⅜ Metal=46.2 lbs.=13.6 sq. in. r (min.)=1.88.	$\frac{7}{16}$ Metal=54.3 lbs.=16.0 sq. in. r (min.)=1.93.	½ Metal=59.9 lbs.=17.6 sq. in. r (min.)=1.90.	$\frac{9}{16}$ Metal=67.9 lbs.=20.0 sq. in. r (min.)=1.95.
12 and under	55.9	70.3	81.6	95.8	105.7	119.8
14	55.7	70.3	81.6	95.8	105.7	119.8
16	52.3	66.5	76.6	91.3	99.9	114.8
18	48.8	62.3	71.7	85.6	93.6	107.8
20	45.4	58.1	66.7	79.9	87.2	100.8
22	42.0	53.9	61.8	74.3	80.9	93.8
24	38.6	49.7	56.9	68.6	74.6	86.8
26	35.2	45.5	51.9	63.0	68.2	79.8
28	31.7	41.3	47.0	57.3	61.9	72.8
30	28.3	37.1	42.0	51.7	55.5	65.8

8″ Z-BAR COLUMNS.

Section: 4 Z-Bars 4″ deep and 1 Web Plate 6½″×thickness of Z-Bars.

Length of Column, in Feet.	¼ Metal=38.3 lbs.=11.3 sq. in. r (min.)=2.47.	$\frac{5}{16}$ Metal=48.1 lbs.=14.1 sq. in. r (min.)=2.52.	⅜ Metal=58.0 lbs.=17.1 sq. in. r (min.)=2.57.	$\frac{7}{16}$ Metal=64.7 lbs.=19.0 sq. in. r (min.)=2.49.	½ Metal=73.7 lbs.=21.9 sq. in. r (min.)=2.55.	$\frac{9}{16}$ Metal=84.1 lbs.=24.8 sq. in. r (min.)=2.60.	⅝ Metal=89.2 lbs.=26.3 sq. in. r (min.)=2.52.	$\frac{11}{16}$ Metal=98.8 lbs.=29.0 sq. in. r (min.)=2.58.	¾ Metal=108.4 lbs.=31.9 sq. in. r (min.)=2.63.
18 and under	67.5	84.8	102.4	114.2	131.2	148.5	157.5	174.3	191.2
20	65.0	82.5	100.5	110.5	128.2	146.4	153.3	171.3	189.6
22	61.9	78.7	95.9	105.3	122.4	139.9	146.2	163.5	181.3
24	58.8	74.8	91.3	100.1	116.5	133.4	139.1	155.8	173.0
26	55.7	71.0	86.8	94.8	110.6	126.9	132.0	148.1	164.7
28	52.6	67.1	82.3	89.6	104.7	120.3	124.8	140.4	156.4
30	49.4	63.3	77.7	84.4	98.8	113.8	117.7	132.7	148.2
32	46.3	59.5	73.2	79.2	93.0	107.3	110.6	125.0	139.9
34	43.2	55.6	68.7	74.0	87.1	100.8	103.5	117.3	131.6
36	40.1	51.8	64.1	68.7	81.2	94.3	96.4	109.6	123.3
38	37.0	48.0	59.6	63.5	75.3	87.8	89.4	101.9	115.0
40	33.9	44.1	55.0	58.3	69.5	81.3	82.2	94.2	106.7

Z-BAR COLUMN DIMENSIONS.



6″ COLUMNS.

4 Z-Bars 3-3 1/16″ deep.

1 Web Plate 5¾″ × thickness of Z-Bars.

Diameter of Bolt or Rivet, ¾″.

Thickness of Metal.	A	B	C	D	E	F	G	H	I
1/4	12 5/16	3 1/8	5 5/16	2 7/8	2 1/2	1 5/8	2 11/16	8 1/2	3 1/4
5/16	12 3/8	3 7/32	5 5/16	2 7/8	2 1/2	1 5/8	2 3/4	8 3/8	3 3/8
3/8	12 3/16	3 3/16	5 3/16	2 7/8	2 1/2	1 5/8	2 11/16	8 1/4	3 3/8
7/16	12 1/4	3 9/32	5 3/16	2 7/8	2 1/2	1 5/8	2 3/4	8 1/8	3 1/2
1/2	12	3 1/4	5 1/16	2 7/8	2 1/2	1 5/8	2 11/16	8	3 1/2
9/16	12 1/16	3 11/32	5 1/16	2 7/8	2 1/2	1 5/8	2 3/4	7 7/8	3 5/8

8″ COLUMNS.

4 Z-Bars 4-4⅛″ deep.

1 Web Plate 6½″ × thickness of Z-Bars.

Diameter of Bolt or Rivet, ¾″.

Thickness of Metal.	A	B	C	D	E	F	G	H	I
1/4	14 11/16	4 1/8	6 1/16	3 1/4	3	1 3/4	3 1/16	9 1/2	4 1/4
5/16	14 3/4	4 7/32	6 1/16	3 1/4	3	1 3/4	3 1/8	9 3/8	4 3/8
3/8	14 13/16	4 5/16	6 1/16	3 1/4	3	1 3/4	3 3/16	9 1/4	4 1/2
7/16	14 1/2	4 7/32	5 7/8	3 1/4	3	1 3/4	3 1/16	9 1/8	4 7/16
1/2	14 9/16	4 5/16	5 7/8	3 1/4	3	1 3/4	3 1/8	9	4 9/16
9/16	14 5/8	4 13/32	5 7/8	3 1/4	3	1 3/4	3 3/16	8 7/8	4 11/16
5/8	14 1/4	4 5/16	5 11/16	3 1/4	3	1 3/4	3 1/16	8 3/4	4 5/8
11/16	14 5/16	4 13/32	5 11/16	3 1/4	3	1 3/4	3 1/8	8 5/8	4 3/4
3/4	14 3/8	4 1/2	5 11/16	3 1/4	3	1 3/4	3 3/16	8 1/2	4 7/8

SAFE LOADS IN TONS OF 2,000 LBS.
Z-BAR COLUMNS.
SQUARE ENDS.

Allowed strains per square inch; safety factor 4:	12,000 lbs., for lengths of 90 radii or under.
	$17{,}100-57\frac{l}{r}$, for lengths over 90 radii.

10″ Z-BAR COLUMNS.

Section: 4 Z-Bars 5″ deep and 1 Web Plate 7″ × thickness of Z-Bars.

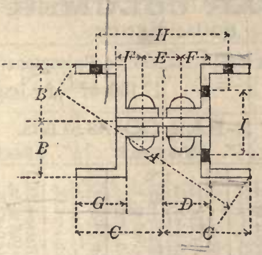
Length of Column, in Feet.	5/16 Metal—53.7 lbs.—15.8 sq. in. r (min.)—3.08.	3/8 Metal—64.7 lbs.—19.0 sq. in. r (min.)—3.13.	7/16 Metal—75.8 lbs.—22.3 sq. in. r (min.)—3.18.	1/2 Metal—83.3 lbs.—24.5 sq. in. r (min.)—3.10.	9/16 Metal—94.2 lbs.—27.7 sq. in. r (min.)—3.15.	5/8 Metal—105.2 lbs.—30.9 sq. in. r (min.)—3.21.	11/16 Metal—111.0 lbs.—32.7 sq. in. r (min.)—3.13.	3/4 Metal—122.8 lbs.—35.8 sq. in. r (min.)—3.18.	13/16 Metal—132.6 lbs.—39.0 sq. in. r (min.)—3.25.
22 and under	94.7	114.2	133.9	147.0	166.2	185.6	196.0	214.9	234.0
24	92.8	112.6	133.1	144.6	164.8	185.3	193.6	213.9	234.0
26	89.3	108.6	128.3	139.2	158.7	178.7	186.5	206.2	226.6
28	85.8	104.4	123.5	133.8	152.7	172.1	179.3	198.5	218.4
30	82.3	100.2	118.7	128.4	146.7	165.5	172.2	190.8	210.2
32	78.8	96.1	113.8	123.0	140.7	158.9	165.0	183.1	202.0
34	75.3	91.9	109.1	117.6	134.7	152.3	157.9	175.4	193.8
36	71.8	87.8	104.3	112.2	128.7	145.7	150.7	167.8	185.6
38	68.3	83.6	99.5	106.8	122.7	139.1	143.6	160.0	177.4
40	64.8	79.4	94.7	101.4	116.7	132.5	136.5	152.3	169.1
42	61.3	75.3	89.9	96.0	110.6	125.9	129.4	144.6	160.9
44	57.7	71.1	85.1	90.6	104.6	119.3	122.2	136.9	152.7
46	54.2	67.0	80.3	85.2	98.6	112.7	115.1	129.2	144.5
48	50.7	62.8	75.5	79.8	92.6	106.1	107.9	121.5	136.3
50	47.2	58.6	70.7	74.4	86.6	99.5	100.8	113.8	128.1

12″ Z-BAR COLUMNS.

Section: 4 Z-Bars 6″ deep and 1 Web Plate 8″ × thickness of Z-Bars.

Length of Column, in Feet.	3/8 Metal—72.7 lbs.—21.4 sq. in. r (min.)—3.67.	7/16 Metal—85.2 lbs.—25.0 sq. in. r (min.)—3.72.	1/2 Metal—97.8 lbs.—28.8 sq. in. r (min.)—3.77.	9/16 Metal—106.2 lbs.—31.2 sq. in. r (min.)—3.70.	5/8 Metal—118.5 lbs.—34.8 sq. in. r (min.)—3.75.	11/16 Metal—130.9 lbs.—38.5 sq. in. r (min.)—3.73.	3/4 Metal—137.8 lbs.—40.5 sq. in. r (min.)—3.68.	13/16 Metal—149.9 lbs.—44.1 sq. in. r (min.)—3.66.	7/8 Metal—162.1 lbs.—47.7 sq. in. r (min.)—3.64.
26 and under	128.3	150.3	172.6	187.3	209.1	231.0	243.0	264.5	286.1
28	127.0	149.7	172.5	186.0	208.9	230.3	240.8	261.4	282.1
30	123.0	145.1	167.6	180.2	202.5	223.3	233.2	253.2	273.2
32	119.0	140.5	162.4	174.5	196.1	216.3	225.7	245.0	264.2
34	115.1	135.9	157.2	168.7	189.8	209.2	218.2	236.7	255.2
36	111.1	131.3	152.0	162.9	183.4	202.1	210.6	228.4	246.3
38	107.1	126.7	146.8	157.1	177.0	195.1	203.1	220.2	237.3
40	103.1	122.1	141.5	151.4	170.7	188.0	195.6	211.9	228.3
42	99.1	117.5	136.3	145.5	164.4	180.9	188.0	203.7	219.4
44	95.1	112.9	131.1	139.8	158.0	173.9	180.5	195.5	210.4
46	91.2	108.3	126.2	134.0	151.6	166.8	172.9	187.2	201.4
48	87.2	103.6	120.7	128.2	145.3	159.8	165.4	179.0	192.4
50	83.2	99.1	115.5	122.4	138.9	152.7	157.9	170.7	183.5

Z-BAR COLUMN DIMENSIONS.



10″ COLUMNS.

4 Z-Bars 5–5⅛″ deep.

1 Web Plate 7″ × thickness of Z-Bars.

Diameter of Bolt or Rivet, ¾″. Thickness of Metal.	A	B	C	D	E	F	G	H	I
$\frac{5}{16}$	16½	5$\frac{5}{32}$	6$\frac{7}{16}$	3½	3¼	1⅞	3¼	10⅛	5$\frac{5}{16}$
⅜	16$\frac{9}{16}$	5¼	6$\frac{7}{16}$	3½	3¼	1⅞	3$\frac{5}{16}$	10	5$\frac{7}{16}$
$\frac{7}{16}$	16⅝	5$\frac{11}{32}$	6$\frac{7}{16}$	3½	3¼	1⅞	3⅜	9⅞	5$\frac{9}{16}$
½	16⅜	5¼	6¼	3½	3¼	1⅞	3¼	9¾	5½
$\frac{9}{16}$	16$\frac{7}{16}$	5$\frac{11}{32}$	6¼	3½	3¼	1⅞	3$\frac{5}{16}$	9⅝	5⅝
⅝	16½	5$\frac{7}{16}$	6¼	3½	3¼	1⅞	3⅜	9½	5¾
$\frac{11}{16}$	16$\frac{3}{16}$	5$\frac{11}{32}$	6$\frac{1}{16}$	3½	3¼	1⅞	3¼	9⅜	5$\frac{11}{16}$
¾	16¼	5$\frac{7}{16}$	6$\frac{1}{16}$	3½	3¼	1⅞	3$\frac{5}{16}$	9¼	5$\frac{13}{16}$
$\frac{13}{16}$	16$\frac{5}{16}$	5$\frac{17}{32}$	6$\frac{1}{16}$	3½	3¼	1⅞	3⅜	9⅛	5$\frac{15}{16}$

12″ COLUMNS.

4 Z-Bars 6-6⅛″ deep.

1 Web Plate 8″ × thickness of Z-Bars.

Diameter of Bolt or Rivet, ¾″. Thickness of Metal.	A	B	C	D	E	F	G	H	I
⅜	18⅞	6$\frac{3}{16}$	7⅛	4	4	2	3½	11¼	6⅜
$\frac{7}{16}$	18$\frac{15}{16}$	6$\frac{9}{32}$	7⅛	4	4	2	3$\frac{9}{16}$	11⅛	6⅝
½	19	6⅜	7⅛	4	4	2	3⅝	11	6¾
$\frac{9}{16}$	18$\frac{11}{16}$	6$\frac{9}{32}$	6$\frac{15}{16}$	4	4	2	3½	10⅞	6$\frac{9}{16}$
⅝	18¾	6⅜	6$\frac{15}{16}$	4	4	2	3$\frac{9}{16}$	10¾	6$\frac{11}{16}$
$\frac{11}{16}$	18$\frac{13}{16}$	6$\frac{15}{32}$	6$\frac{15}{16}$	4	4	2	3⅝	10⅝	6$\frac{13}{16}$
¾	18$\frac{9}{16}$	6⅜	6¾	4	4	2	3½	10½	6¾
$\frac{13}{16}$	18⅝	6$\frac{15}{32}$	6¾	4	4	2	3$\frac{9}{16}$	10⅜	6⅞
⅞	18$\frac{11}{16}$	6$\frac{9}{16}$	6¾	4	4	2	3⅝	10¼	7

SAFE LOADS IN TONS OF 2,000 LBS.

Z-BAR COLUMNS.

SQUARE ENDS.

Allowed strains per square inch; safety factor 4: { 12,000 lbs., for lengths of 90 radii or under. $17{,}100-57\frac{l}{r}$, for lengths over 90 radii.

14″ Z-BAR COLUMNS.

Section: 4 Z-Bars $6\frac{1}{8}''\times\frac{11}{16}''$. 1 Web Plate $8''\times\frac{11}{16}''$. 2 Side Plates 14″ wide

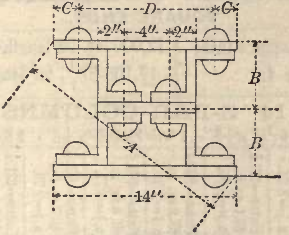
Length of Column, in Feet.	$14\times\frac{3}{8}$ Plates=166.6 lbs.=49.0 sq. in. r (min.)=3.80.	$14\times\frac{7}{16}$ Plates=172.6 lbs.=50.8 sq. in. r (min.)=3.81.	$14\times\frac{1}{2}$ Plates=178.5 lbs.=52.5 sq. in. r (min.)=3.82.	$14\times\frac{9}{16}$ Plates=184.5 lbs.=54.3 sq. in. r (min.)=3.82.	$14\times\frac{5}{8}$ Plates=190.4 lbs.=56.0 sq. in. r (min.)=3.83.	$14\times\frac{11}{16}$ Plates=196.4 lbs.=57.8 sq. in. r (min.)=3.84.	$14\times\frac{3}{4}$ Plates=202.3 lbs.=59.5 sq. in. r (min.)=3.85.	$14\times\frac{13}{16}$ Plates=208.4 lbs.=61.3 sq. in. r (min.)=3.85.	$14\times\frac{7}{8}$ Plates=214.2 lbs.=63.0 sq. in. r (min.)=3.85.
28 and under	294.0	304.5	315.0	325.5	336.0	346.5	357.0	367.5	378.0
30	286.6	297.2	307.7	318.3	328.9	339.5	350.0	360.4	370.9
32	277.8	288.1	298.3	308.6	318.9	329.2	339.4	349.5	359.7
34	269.0	278.9	288.9	298.9	308.9	318.9	328.8	338.6	348.6
36	260.1	269.8	279.5	289.2	298.9	308.6	318.2	327.7	337.4
38	251.3	260.7	270.1	279.5	289.0	298.3	307.6	316.8	326.2
40	242.5	251.6	260.7	269.7	278.9	288.0	297.0	306.0	315.0
42	233.7	242.5	251.3	260.1	269.0	277.8	286.4	295.1	303.8
44	224.9	233.3	241.9	250.4	258.9	267.4	275.8	284.2	292.6
46	216.0	224.3	232.4	240.7	249.0	257.2	265.2	273.3	281.5
48	207.2	215.1	223.0	230.9	238.9	246.9	254.6	262.4	270.3
50	198.4	206.0	213.6	221.3	229.0	236.5	244.0	251.5	259.1

14″ Z-BAR COLUMNS.

Section: 4 Z-Bars $6''\times\frac{3}{4}''$. 1 Web Plate $8''\times\frac{3}{4}''$. 2 Side Plates 14″ wide.

Length of Column, in Feet.	$14\times\frac{3}{8}$ Plates=173.4 lbs.=51.0 sq. in. r (m.n.)=3.75.	$14\times\frac{7}{16}$ Plates=179.4 lbs.=52.8 sq. in. r (m.n.)=3.76.	$14\times\frac{1}{2}$ Plates=185.3 lbs.=54.5 sq. in. r (min.)=3.77.	$14\times\frac{9}{16}$ Plates=191.3 lbs.=56.3 sq. in. r (min.)=3.78.	$14\times\frac{5}{8}$ Plates=197.2 lbs.=58.0 sq. in. r (min.)=3.79.	$14\times\frac{11}{16}$ Plates=203.2 lbs.=59.8 sq. in. r (min.)=3.80.	$14\times\frac{3}{4}$ Plates=209.1 lbs.=61.5 sq. in. r (min.)=3.80.	$14\times\frac{13}{16}$ Plates=215.1 lbs.=63.3 sq. in. r (min.)=3.81.	$14\times\frac{7}{8}$ Plates=221.0 lbs.=65.0 sq. in. r (min.)=3.82.
28 and under	306.0	316.5	327.0	337.5	348.0	358.5	369.0	379.5	390.0
30	296.7	307.2	317.8	328.3	338.9	349.4	359.9	370.5	381.1
32	287.4	297.6	307.9	318.2	328.4	338.7	348.9	359.1	369.4
34	278.1	288.0	298.0	308.0	318.0	327.9	337.8	347.8	357.8
36	268.8	278.4	288.2	297.9	307.4	317.2	326.8	336.4	346.1
38	259.5	268.8	278.3	287.7	297.0	306.4	315.7	325.1	334.5
40	250.2	259.3	268.4	277.5	286.5	295.6	304.7	313.7	322.8
42	240.9	249.7	258.5	267.3	276.1	284.8	293.6	302.4	311.2
44	231.6	240.1	248.6	257.1	265.6	274.1	282.5	291.0	299.6
46	222.4	230.5	238.7	246.9	255.1	263.4	271.5	279.7	287.9
48	213.0	220.9	228.8	236.8	244.7	252.6	260.4	268.3	276.2
50	203.7	211.3	219.0	226.6	234.2	241.8	249.4	257.0	264.6

Z-BAR COLUMN DIMENSIONS.



14″ COLUMNS.

4 Z-Bars $6\frac{1}{8}'' \times \frac{11}{16}''$.
1 Web Plate $8'' \times \frac{11}{16}''$.
2 Side Plates 14″ wide.

	Thickness of Side Plates.	A	B	C	D
Diameter of Bolt or Rivet, ⅞″.	⅜	19 9/16	6 27/32	1 11/16	10⅝
	7/16	19 11/16	6 29/32	1 11/16	10⅝
	½	19¾	6 31/32	1 11/16	10⅝
	9/16	19⅞	7 1/32	1 11/16	10⅝
	⅝	19 15/16	7 3/32	1 11/16	10⅝
	11/16	20 1/16	7 5/32	1 11/16	10⅝
	¾	20⅛	7 7/32	1 11/16	10⅝
	13/16	20¼	7 9/32	1 11/16	10⅝
	⅞	20 5/16	7 11/32	1 11/16	10⅝

14″ COLUMNS.

4 Z-Bars $6'' \times \frac{3}{4}''$.
1 Web Plate $8'' \times \frac{3}{4}''$.
2 Side Plates 14″ wide.

	Thickness of Side Plates.	A	B	C	D
Diameter of Bolt or Rivet, ⅞″.	⅜	19 7/16	6¾	1¾	10½
	7/16	19½	6 13/16	1¾	10½
	½	19⅝	6⅞	1¾	10½
	9/16	19¾	6 15/16	1¾	10½
	⅝	19 13/16	7	1¾	10½
	11/16	19⅞	7 1/16	1¾	10½
	¾	20	7⅛	1¾	10½
	13/16	20 1/16	7 3/16	1¾	10½
	⅞	20⅛	7¼	1¾	10½

SAFE LOADS IN TONS OF 2,000 LBS.
Z-BAR COLUMNS.
SQUARE ENDS.

Allowed strains per square inch; safety factor 4: { 12,000 lbs., for lengths of 90 radii or under. $17{,}100-57\frac{l}{r}$, for lengths over 90 radii.

14″ Z-BAR COLUMNS.

Section: 4 Z-Bars $6\frac{1}{16}''\times\frac{13}{16}''$. 1 Web Plate $8''\times\frac{13}{16}''$. 2 Side Plates 14″ wide.

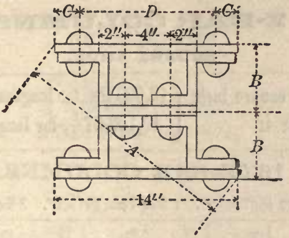
Length of Column, in Feet.	$14\times\frac{3}{8}$ Plates=185.6 lbs.=54.6 sq. in. r (min.)=3.73.	$14\times\frac{7}{16}$ Plates=191.5 lbs.=56.3 sq. in. r (min.)=3.74.	$14\times\frac{1}{2}$ Plates=197.5 lbs.=58.1 sq. in. r (min.)=3.75.	$14\times\frac{9}{16}$ Plates=203.4 lbs.=59.8 sq. in. r (min.)=3.76.	$14\times\frac{5}{8}$ Plates=209.4 lbs.=61.6 sq. in. r (min.)=3.77.	$14\times\frac{11}{16}$ Plates=215.3 lbs.=63.3 sq. in. r (min.)=3.78.	$14\times\frac{3}{4}$ Plates=221.3 lbs.=65.1 sq. in. r (min.)=3.78.	$14\times\frac{13}{16}$ Plates=227.2 lbs.=66.8 sq. in. r (min.)=3.79.	$14\times\frac{7}{8}$ Plates=233.2 lbs.=68.6 sq. in. r (min.)=3.80.
26 and under	327.5	338.0	348.5	359.0	369.5	380.0	390.5	401.0	411.5
28	326.7	337.5	348.5	359.0	369.5	380.0	390.5	401.0	411.5
30	316.7	327.2	337.7	348.3	358.9	369.5	380.0	390.6	401.1
32	306.6	318.0	327.2	337.4	347.7	358.0	368.2	378.5	388.8
34	296.6	306.6	316.6	326.5	336.5	346.5	356.4	366.4	376.4
36	286.7	296.4	306.0	315.7	325.3	335.0	344.7	354.3	364.0
38	276.7	286.0	295.4	304.8	314.2	323.6	332.9	342.3	351.7
40	266.6	275.7	284.8	293.9	303.0	312.1	321.2	330.3	339.3
42	256.6	265.5	274.3	283.0	291.8	300.6	309.4	318.2	327.0
44	246.6	255.2	263.6	272.2	280.6	289.2	297.6	306.1	314.6
46	236.6	244.9	253.0	261.3	269.5	277.7	285.8	294.0	302.3
48	226.7	234.6	242.5	250.4	258.3	266.2	274.1	282.0	290.0
50	216.6	224.3	231.9	239.5	247.1	254.8	262.3	269.9	277.6

14″ Z-BAR COLUMNS.

Section: 4 Z-Bars $6\frac{1}{8}''\times\frac{7}{8}''$. 1 Web Plate $8''\times\frac{7}{8}''$. 2 Side Plates 14″ wide.

Length of Column, in Feet.	$14\times\frac{3}{8}$ Plates=197.8 lbs.=58.2 sq. in. r (min.)=3.71.	$14\times\frac{7}{16}$ Plates=203.8 lbs.=59.9 sq. in. r (min.)=3.72.	$14\times\frac{1}{2}$ Plates=209.7 lbs.=61.7 sq. in. r (min.)=3.73.	$14\times\frac{9}{16}$ Plates=215.7 lbs.=63.4 sq. in. r (min.)=3.74.	$14\times\frac{5}{8}$ Plates=221.6 lbs.=65.2 sq. in. r (min.)=3.75.	$14\times\frac{11}{16}$ Plates=227.6 lbs.=66.9 sq. in. r (min.)=3.76.	$14\times\frac{3}{4}$ Plates=233.5 lbs.=68.7 sq. in. r (min.)=3.77.	$14\times\frac{13}{16}$ Plates=239.5 lbs.=70.4 sq. in. r (min.)=3.77.	$14\times\frac{7}{8}$ Plates=245.4 lbs.=72.2 sq. in. r (min.)=3.78.
26 and under	349.1	359.6	370.1	380.6	391.1	401.6	412.1	422.6	433.1
28	347.4	358.3	369.1	380.0	390.9	401.6	412.1	422.6	433.1
30	336.7	347.2	357.9	368.4	378.9	389.5	400.1	410.7	421.2
32	326.0	336.3	346.6	356.8	367.1	377.3	387.6	397.9	408.2
34	315.3	325.2	335.2	345.2	355.1	365.2	375.2	385.1	395.1
36	304.5	314.2	324.0	333.6	343.3	353.0	362.7	372.4	382.0
38	293.8	303.2	312.6	322.0	331.4	340.8	350.2	359.6	369.0
40	283.1	292.2	301.3	310.4	319.5	328.6	337.7	346.8	355.9
42	272.3	281.2	290.0	298.8	307.6	316.4	325.2	334.0	342.8
44	261.6	270.2	278.7	287.2	295.7	304.2	312.7	321.2	329.8
46	250.9	259.1	267.4	275.6	283.8	292.1	300.3	308.5	316.7
48	240.2	248.1	256.1	264.0	272.0	279.8	287.8	295.7	303.6
50	229.5	237.1	244.8	252.4	260.0	267.6	275.3	283.0	290.6

Z-BAR COLUMN DIMENSIONS.



14″ COLUMNS.

4 Z-Bars $6\frac{1}{16}'' \times \frac{13}{16}''$.
1 Web Plate $8'' \times \frac{13}{16}''$.
2 Side Plates 14″ wide.

	Thickness of Side Plates.	A	B	C	D
Diameter of Bolt or Rivet, 7/8″.	3/8	19 9/16	6 27/32	1 13/16	10 3/8
	7/16	19 5/8	6 29/32	1 13/16	10 3/8
	1/2	19 3/4	6 31/32	1 13/16	10 3/8
	9/16	19 7/8	7 1/32	1 13/16	10 3/8
	5/8	19 15/16	7 3/32	1 13/16	10 3/8
	11/16	20 1/16	7 5/32	1 13/16	10 3/8
	3/4	20 1/8	7 7/32	1 13/16	10 3/8
	13/16	20 3/16	7 9/32	1 13/16	10 3/8
	7/8	20 1/4	7 11/32	1 13/16	10 3/8

14″ COLUMNS.

4 Z-Bars $6\frac{1}{8}'' \times \frac{7}{8}''$.
1 Web Plate $8'' \times \frac{7}{8}''$.
2 Side Plates 14″ wide.

	Thickness of Side Plates.	A	B	C	D
Diameter of Bolt or Rivet, 7/8″.	3/8	19 3/4	6 15/16	1 7/8	10 1/4
	7/16	19 13/16	7	1 7/8	10 1/4
	1/2	19 7/8	7 1/16	1 7/8	10 1/4
	9/16	20	7 1/8	1 7/8	10 1/4
	5/8	20 1/16	7 3/16	1 7/8	10 1/4
	11/16	20 1/8	7 1/4	1 7/8	10 1/4
	3/4	20 1/4	7 5/16	1 7/8	10 1/4
	13/16	20 5/16	7 3/8	1 7/8	10 1/4
	7/8	20 7/16	7 7/16	1 7/8	10 1/4

SAFE LOADS IN TONS OF 2,000 LBS.

Z-BAR COLUMNS.

SQUARE ENDS.

Allowed strains per square inch; safety factor 4: 12,000 lbs., for lengths of 90 radii or under. 17,100-57 $\frac{l}{r}$, for lengths over 90 radii.

16″ Z-BAR COLUMNS.

Section: 4 Z-Bars 6⅛″×⅞″. 1 Web Plate 10″×1″. 2 Side Plates 16″ wide.

Length of Column, in Feet.	16×½ Plates=226.7 lbs.=66.7 sq. in. r (min.)=4.50.	16×$\frac{9}{16}$ Plates=233.5 lbs.=68.7 sq. in. r (min.)=4.50.	16×⅝ Plates=240.3 lbs.=70.7 sq. in. r (min.)=4.50.	16×$\frac{11}{16}$ Plates=247.1 lbs.=72.7 sq. in. r (min.)=4.51.	16×¾ Plates=253.9 lbs.=74.7 sq. in. r (min.)=4.51.	16×$\frac{13}{16}$ Plates=260.7 lbs.=76.7 sq. in. r (min.)=4.51.	16×⅞ Plates=267.5 lbs.=78.7 sq. in. r (min.)=4.52.	16×$\frac{15}{16}$ Plates=274.3 lbs.=80.7 sq. in. r (min.)=4.52.	16×1 Plates=281.1 lbs.=82.7 sq. in. r (min.)=4.52.
32 and under	400.1	412.1	424.1	436.1	448.1	460.1	472.1	484.1	496.1
34	397.7	409.8	421.9	433.9	446.0	458.1	470.2	482.2	494.2
36	387.6	399.3	411.1	422.9	434.7	446.5	458.2	470.0	481.8
38	377.5	388.9	400.4	411.8	423.4	434.8	446.3	457.9	469.3
40	367.3	378.5	389.6	400.9	412.1	423.2	434.4	445.6	456.7
42	357.1	368.0	378.9	389.8	400.7	411.6	422.5	433.4	444.3
44	347.0	357.6	368.2	378.8	389.4	400.0	410.5	421.1	431.7
46	336.9	347.1	357.4	367.7	378.1	388.4	398.6	409.0	419.2
48	326.7	336.7	346.7	356.7	366.7	376.8	386.7	396.7	406.7
50	316.6	326.3	336.0	345.7	355.4	365.1	374.8	384.5	394.2

18″ Z-BAR COLUMNS.

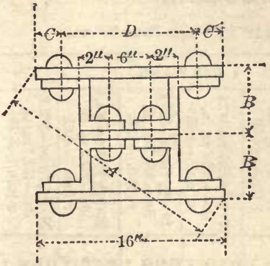
Section: 4 Z-Bars 6⅛″×⅞″. 1 Web Plate 12″×1″. 2 Side Plates 18″ wide.

Length of Column, in Feet.	18×½ Plates=240.4 lbs.=70.7 sq. in. r (min.)=4.71.	18×$\frac{9}{16}$ Plates=248.0 lbs.=72.9 sq. in. r (min.)=4.81.	18×⅝ Plates=255.7 lbs.=75.2 sq. in. r (min.)=4.90.	18×$\frac{11}{16}$ Plates=263.0 lbs.=77.4 sq. in. r (min.)=4.98.	18×¾ Plates=271.0 lbs.=79.7 sq. in. r (min.)=5.06.	18×$\frac{13}{16}$ Plates=278.6 lbs.=81.9 sq. in. r (min.)=5.14.	18×⅞ Plates=286.3 lbs.=84.2 sq. in. r (min.)=5.22.	18×$\frac{15}{16}$ Plates=293.9 lbs.=86.4 sq. in. r (min.)=5.26.	18×1 Plates=301.6 lbs.=88.7 sq. in. r (min.)=5.26.
34 and under	424.1	437.6	451.1	464.6	478.1	491.6	505.1	518.6	532.1
36	419.7	436.8	451.1	464.6	478.1	491.6	505.1	518.6	532.1
38	409.4	426.4	443.2	456.2	476.8	491.6	505.1	518.6	532.1
40	399.2	416.0	432.7	449.5	466.0	482.6	499.1	514.2	527.5
42	388.9	405.6	422.3	438.8	455.3	471.7	488.1	503.0	516.0
44	378.7	395.2	411.7	428.2	444.5	460.8	477.0	491.8	504.5
46	368.4	384.9	401.2	417.5	433.8	449.9	466.0	480.5	493.0
48	358.1	374.5	390.7	406.9	423.0	439.0	454.9	469.3	481.4
50	347.9	364.1	380.2	396.2	412.2	428.1	443.9	458.1	469.9

Z-BAR COLUMN DIMENSIONS.

16″ COLUMNS.

4 Z-Bars 6⅛″ × ⅞″.
1 Web Plate 10″ × 1″.
2 Side Plates 16″ wide.

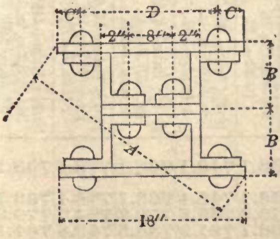


Diameter of Bolts or Rivets, ⅞″.

Thickness of Side Plates.	A	B	C	D
½	21 7/16	7⅛	1⅞	12¼
9/16	21½	7 3/16	1⅞	12¼
⅝	21 9/16	7¼	1⅞	12¼
11/16	21 11/16	7 5/16	1⅞	12¼
¾	21¾	7⅜	1⅞	12¼
13/16	21 13/16	7 7/16	1⅞	12¼
⅞	21 15/16	7½	1⅞	12¼
15/16	22	7 9/16	1⅞	12¼
1	22 1/16	7⅝	1⅞	12¼

18″ COLUMNS.

4 Z-Bars 6⅛″ × ⅞″.
1 Web Plate 12″ × 1″.
2 Side Plates 18″ wide.



Diameter of Bolts or Rivets, ⅞″.

Thickness of Side Plates.	A	B	C	D
½	23	7⅛	1⅞	14¼
9/16	23 1/16	7 3/16	1⅞	14¼
⅝	23⅛	7¼	1⅞	14¼
11/16	23 3/16	7 5/16	1⅞	14¼
¾	23¼	7⅜	1⅞	14¼
13/16	23 5/16	7 7/16	1⅞	14¼
⅞	23 7/16	7½	1⅞	14¼
15/16	23½	7 9/16	1⅞	14¼
1	23⅝	7⅝	1⅞	14¼

SAFE LOADS IN TONS OF 2,000 LBS.

Z-BAR COLUMNS.

SQUARE ENDS.

Allowed strains per square inch; safety factor 4: { 12,000 lbs., for lengths of 90 radii or under. 17,100–57 $\frac{l}{r}$, for lengths over 90 radii.

20″ Z-BAR COLUMNS.

Section: 4 Z-Bars $6\frac{1}{8}''\times\frac{7}{8}''$. 1 Web Plate $14''\times1''$. Side Plates 20″ wide.

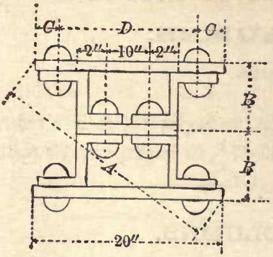
Length of Column, in Feet.	2 SIDE PLATES.			4 SIDE PLATES.					
	$20\times\frac{7}{8}$ Plates=304.9 lbs.=89.7 sq. in. r (min.)=5.24.	$20\times\frac{15}{16}$ Plates=313.4 lbs.=92.2 sq. in. r (min.)=5.32.	20×1 Plates=321.9 lbs.=94.7 sq. in. r (min.)=5.39.	$20\times1\frac{1}{16}$ Plates=330.4 lbs.=97.2 sq. in. r (min.)=5.44.	$20\times1\frac{1}{8}$ Plates=338.9 lbs.=99.7 sq. in. r (min.)=5.50.	$20\times1\frac{3}{16}$ Plates=347.4 lbs.=102.2 sq. in. r (min.)=5.55.	$20\times1\frac{1}{4}$ Plates=355.9 lbs.=104.7 sq. in. r (min.)=5.60.	$20\times1\frac{5}{16}$ Plates=364.4 lbs.=107.2 sq. in. r (min.)=5.65.	$20\times1\frac{3}{8}$ Plates=372.9 lbs.=109.7 sq. in. r (min.)=5.69.
38 and under	538.1	553.1	568.1	583.1	598.1	613.1	628.1	643.1	658.1
40	532.9	551.1	568.1	583.1	598.1	613.1	628.1	643.1	658.1
42	521.2	539.2	557.2	574.5	591.9	609.0	626.4	643.1	658.1
44	509.5	527.3	545.3	562.3	579.4	596.5	613.7	630.7	648.0
46	497.7	515.5	533.3	550.1	567.0	583.8	600.9	617.8	634.8
48	486.1	503.6	521.2	538.0	554.6	571.2	588.1	604.8	621.6
50	474.4	491.8	509.2	525.7	542.2	558.6	575.2	591.8	608.4

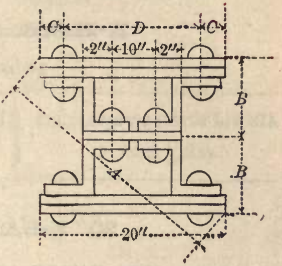
20″ Z-BAR COLUMNS.

Section: 4 Z-Bars $6\frac{1}{8}''\times\frac{7}{8}''$. 1 Web Plate $14''\times1''$. 4 Side Plates 20″ wide.

Length of Column, in Feet.	$20\times1\frac{7}{16}$ Plates=381.5 lbs.=112.2 sq. in. r (min.)=5.74.	$20\times1\frac{1}{2}$ Plates=390.0 lbs.=114.7 sq. in. r (min.)=5.79.	$20\times1\frac{9}{16}$ Plates=398.5 lbs.=117.2 sq. in. r (min.)=5.83.	$20\times1\frac{5}{8}$ Plates=407.0 lbs.=119.7 sq. in. r (min.)=5.88.	$20\times1\frac{11}{16}$ Plates=415.5 lbs.=122.2 sq. in. r (min.)=5.92.	$20\times1\frac{3}{4}$ Plates=424.0 lbs.=124.7 sq. in. r (min.)=5.93.	$20\times1\frac{13}{16}$ Plates=432.5 lbs.=127.2 sq. in. r (min.)=5.93.	$20\times1\frac{7}{8}$ Plates=441.0 lbs.=129.7 sq. in. r (min.)=5.93.	$20\times1\frac{15}{16}$ Plates=449.5 lbs.=132.2 sq. in. r (min.)=5.93.
42 and under	673.1	688.1	703.1	718.1	733.1	748.1	763.1	778.1	793.1
44	665.0	682.5	699.7	717.0	733.1	748.1	763.1	778.1	793.1
46	651.7	668.8	686.0	703.1	720.2	735.6	750.2	764.7	779.3
48	638.4	655.3	672.2	689.2	706.1	721.2	735.5	749.8	764.1
50	625.0	641.7	658.4	675.3	692.0	706.8	720.8	734.8	748.8

Z-BAR COLUMN DIMENSIONS.





20″ COLUMNS.

4 Z-Bars, $6\frac{1}{8}'' \times \frac{7}{8}''$.

1 Web Plate, $14'' \times 1''$.

Side Plates 20″ wide.

	Thickness of Metal on Each Side.	A	B	C	D	Number of Side Plates.
Diameter of Bolts or Rivets, $\frac{7}{8}''$.	$\frac{7}{8}$	25	$7\frac{1}{2}$	$1\frac{7}{8}$	$16\frac{1}{4}$	Two.
	$\frac{15}{16}$	$25\frac{1}{16}$	$7\frac{9}{16}$	$1\frac{7}{8}$	$16\frac{1}{4}$	"
	1	$25\frac{3}{16}$	$7\frac{5}{8}$	$1\frac{7}{8}$	$16\frac{1}{4}$	"
	$1\frac{1}{16}$	$25\frac{1}{4}$	$7\frac{11}{16}$	$1\frac{7}{8}$	$16\frac{1}{4}$	"
	$1\frac{1}{8}$	$25\frac{5}{16}$	$7\frac{3}{4}$	$1\frac{7}{8}$	$16\frac{1}{4}$	"
	$1\frac{3}{16}$	$25\frac{3}{8}$	$7\frac{13}{16}$	$1\frac{7}{8}$	$16\frac{1}{4}$	Four.
	$1\frac{1}{4}$	$25\frac{7}{16}$	$7\frac{7}{8}$	$1\frac{7}{8}$	$16\frac{1}{4}$	"
	$1\frac{5}{16}$	$25\frac{9}{16}$	$7\frac{15}{16}$	$1\frac{7}{8}$	$16\frac{1}{4}$	"
	$1\frac{3}{8}$	$25\frac{5}{8}$	8	$1\frac{7}{8}$	$16\frac{1}{4}$	"
	$1\frac{7}{16}$	$25\frac{3}{4}$	$8\frac{1}{16}$	$1\frac{7}{8}$	$16\frac{1}{4}$	"
	$1\frac{1}{2}$	$25\frac{13}{16}$	$8\frac{1}{8}$	$1\frac{7}{8}$	$16\frac{1}{4}$	"
	$1\frac{9}{16}$	$25\frac{7}{8}$	$8\frac{3}{16}$	$1\frac{7}{8}$	$16\frac{1}{4}$	"
	$1\frac{5}{8}$	$25\frac{15}{16}$	$8\frac{1}{4}$	$1\frac{7}{8}$	$16\frac{1}{4}$	"
	$1\frac{11}{16}$	$26\frac{1}{16}$	$8\frac{5}{16}$	$1\frac{7}{8}$	$16\frac{1}{4}$	"
	$1\frac{3}{4}$	$26\frac{1}{8}$	$8\frac{3}{8}$	$1\frac{7}{8}$	$16\frac{1}{4}$	"
	$1\frac{13}{16}$	$26\frac{3}{16}$	$8\frac{7}{16}$	$1\frac{7}{8}$	$16\frac{1}{4}$	"
	$1\frac{7}{8}$	$26\frac{1}{4}$	$8\frac{1}{2}$	$1\frac{7}{8}$	$16\frac{1}{4}$	"
	$1\frac{15}{16}$	$26\frac{5}{16}$	$8\frac{9}{16}$	$1\frac{7}{8}$	$16\frac{1}{4}$	"

SAFE LOADS IN TONS OF 2,000 LBS.

Z-BAR COLUMNS.

SQUARE ENDS.

Allowed strains per square inch; safety factor 4: { 12,000 lbs., for lengths of 90 radii or under. $17{,}100-57\frac{l}{r}$, for lengths over 90 radii.

20″ Z-BAR COLUMNS.

Section: 4 Z-Bars $6\frac{1}{8}''\times\frac{7}{8}''$. 1 Web Plate $14''\times1''$. 6 Side Plates 20″ wide.

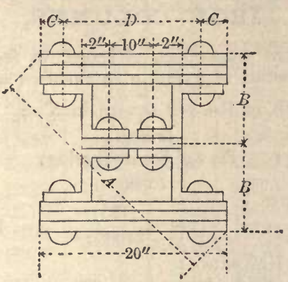
Length of Column, in Feet.	20x2 Plates=458.0 lbs.=134.7 sq. in. r (min.)=5.92.	$20\times2\frac{1}{16}$ Plates=466.5 lbs.=137.2 sq. in. r (min.)=5.92.	$20\times2\frac{1}{8}$ Plates=475.0 lbs.=139.7 sq. in. r (min.)=5.92.	$20\times2\frac{3}{16}$ Plates=483.5 lbs.=142.2 sq. in. r (min.)=5.92.	$20\times2\frac{1}{4}$ Plates=492.0 lbs.=144.7 sq. in. r (min.)=5.91.	$20\times2\frac{5}{16}$ Plates=500.5 lbs.=147.2 sq. in. r (min.)=5.91.	$20\times2\frac{3}{8}$ Plates=509.0 lbs.=149.7 sq. in. r (min.)=5.91.	$20\times2\frac{7}{16}$ Plates=517.5 lbs.=152.2 sq. in. r (min.)=5.91.	$20\times2\frac{1}{2}$ Plates=526.0 lbs.=154.7 sq. in. r (min.)=5.90.
44 and under	808.1	823.1	838.1	853.1	868.1	883.1	898.1	913.1	928.1
46	793.7	808.3	823.0	837.5	852.1	866.7	881.2	895.8	910.4
48	778.2	792.5	806.9	821.2	835.5	849.7	864.0	878.3	892.6
50	762.6	776.7	790.8	804.7	818.7	832.8	846.7	860.7	874.7

20″ Z-BAR COLUMNS.

Section: 4 Z-Bars $6\frac{1}{8}''\times\frac{7}{8}''$. 1 Web Plate $14''\times1''$. 6 Side Plates 20″ wide.

Length of Column, in Feet.	$20\times2\frac{9}{16}$ Plates=534.5 lbs.=157.2 sq. in. r (min.)=5.90.	$20\times2\frac{5}{8}$ Plates=543.0 lbs.=159.7 sq. in. r (min.)=5.90.	$20\times2\frac{11}{16}$ Plates=551.5 lbs.=162.2 sq. in. r (min.)=5.90.	$20\times2\frac{3}{4}$ Plates=560.0 lbs.=164.7 sq. in. r (min.)=5.90.	$20\times2\frac{13}{16}$ Plates=568.5 lbs.=167.2 sq. in. r (min.)=5.89.	$20\times2\frac{7}{8}$ Plates=577.0 lbs.=169.7 sq. in. r (min.)=5.89.	$20\times2\frac{15}{16}$ Plates=585.5 lbs.=172.2 sq. in. r (min.)=5.89.	20x3 Plates=594.0 lbs.=174.7 sq. in. r (min.)=5.89.
42 and under	943.1	958.1	973.1	988.1	1003.1	1018.1	1033.1	1048.1
44	943.1	958.1	973.0	987.8	1002.5	1017.5	1032.3	1047.3
46	925.0	939.6	954.2	968.8	983.3	997.7	1012.3	1026.8
48	906.9	921.1	935.4	949.6	963.9	978.1	992.3	1006.5
50	888.7	902.6	916.6	930.5	944.5	958.4	972.4	986.1

Z-BAR COLUMN DIMENSIONS.



20″ COLUMNS.

4 Z-Bars, 6 1/8″ × 7/8″.
1 Web Plate, 14″ × 1″.
6 Side Plates, 20″ wide.

Diameter of Bolts or Rivets, 7/8″.

Thickness of Metal on Each Side.	A	B	C	D
2	26 3/8	8 5/8	1 7/8	16 1/4
2 1/16	26 1/2	8 11/16	1 7/8	16 1/4
2 1/8	26 9/16	8 3/4	1 7/8	16 1/4
2 3/16	26 5/8	8 13/16	1 7/8	16 1/4
2 1/4	26 3/4	8 7/8	1 7/8	16 1/4
2 5/16	26 13/16	8 15/16	1 7/8	16 1/4
2 3/8	26 15/16	9	1 7/8	16 1/4
2 7/16	27 1/16	9 1/16	1 7/8	16 1/4
2 1/2	27 1/8	9 1/8	1 7/8	16 1/4
2 9/16	27 3/16	9 3/16	1 7/8	16 1/4
2 5/8	27 1/4	9 1/4	1 7/8	16 1/4
2 11/16	27 3/8	9 5/16	1 7/8	16 1/4
2 3/4	27 7/16	9 3/8	1 7/8	16 1/4
2 13/16	27 1/2	9 7/16	1 7/8	16 1/4
2 7/8	27 9/16	9 1/2	1 7/8	16 1/4
2 15/16	27 5/8	9 9/16	1 7/8	16 1/4
3	27 3/4	9 5/8	1 7/8	16 1/4

ULTIMATE STRENGTH OF WROUGHT IRON COLUMNS,

For different proportions of length in feet (= l)
To least radius of gyration in inches (= r).

Ultimate Strength in lbs. per square inch =

Column Square Bearing:	Column Pin and Square Bearing:	Column Pin Bearing:
$\dfrac{40000}{1 + \dfrac{(12\,l)^2}{36000\,r^2}}$	$\dfrac{40000}{1 + \dfrac{(12\,l)^2}{24000\,r^2}}$	$\dfrac{40000}{1 + \dfrac{(12\,l)^2}{18000\,r^2}}$

To obtain Safe Resistance:

For quiescent loads, as in buildings, divide by 4.
For moving loads, as in bridges, divide by 5.

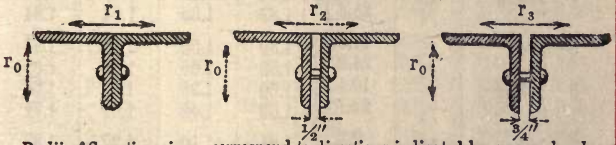
$\frac{l}{r}$	Ultimate Strength in Lbs. per square inch.			$\frac{l}{r}$	Ultimate Strength in Lbs. per square inch.		
	Square.	Pin and Square.	Pin.		Square.	Pin and Square.	Pin.
3.0	38610	37950	37310	8.0	31850	28900	26460
3.2	38430	37680	36970	8.2	31520	28500	26010
3.4	38230	37400	36610	8.4	31190	28100	25570
3.6	38030	37110	36240	8.6	30870	27700	25130
3.8	37820	36810	35860	8.8	30540	27310	24700
4.0	37590	36500	35460	9.0	30210	26920	24270
4.2	37360	36170	35050	9.2	29880	26530	23850
4.4	37120	35840	34640	9.4	29550	26140	23430
4.6	36870	35500	34210	9.6	29230	25760	23030
4.8	36620	35140	33770	9.8	28900	25370	22620
5.0	36360	34780	33330	10.0	28570	25000	22220
5.2	36090	34420	32890	10.2	28250	24630	21830
5.4	35820	34050	32440	10.4	27920	24260	21440
5.6	35540	33670	31980	10.6	27600	23890	21060
5.8	35260	33280	31520	10.8	27270	23530	20690
6.0	34970	32890	31060	11.0	26950	23170	20330
6.2	34670	32500	30590	11.2	26640	22820	19960
6.4	34370	32110	30130	11.4	26320	22470	19610
6.6	34060	31710	29670	11.6	26000	22130	19270
6.8	33750	31310	29200	11.8	25690	21800	18930
7.0	33440	30910	28740	12.0	25380	21460	18590
7.2	33130	30510	28270	12.2	25070	21130	18260
7.4	32810	30110	27820	12.4	24770	20810	17940
7.6	32490	29710	27360	12.6	24470	20490	17620
7.8	32170	29310	26910	12.8	24170	20180	17310

ULTIMATE STRENGTH OF WROUGHT IRON COLUMNS.—Continued.

13.0	23870	19860	17000	17.0	18550	14630	12080
13.2	23570	19560	16710	17.2	18320	14410	11880
13.5	23140	19110	16280	17.5	17980	14100	11590
13.8	22700	18670	15850	17.8	17640	13790	11320
14.0	22420	18380	15580	18.0	17420	13590	11140
14.2	22150	18100	15310	18.2	17200	13390	10960
14.5	21740	17690	14920	18.5	16880	13100	10700
14.8	21320	17290	14530	18.8	16570	12820	10450
15.0	21050	17020	14290	19.0	16370	12630	10290
15.2	20790	16760	14040	19.2	16170	12450	10130
15.5	20290	16390	13690	19.5	15870	12190	9890
15.8	20020	16010	13350	19.8	15570	11930	9670
16.0	19760	15770	13120	20.0	15380	11760	9520
16.2	19510	15540	12910	20.2	15200	11600	9380
16.5	19150	15190	12590	20.5	14920	11360	9170
16.8	18790	14850	12280	20.8	14650	11120	8970

RADII OF GYRATION FOR TWO ANGLES PLACED BACK TO BACK.

ANGLES WITH EQUAL LEGS.



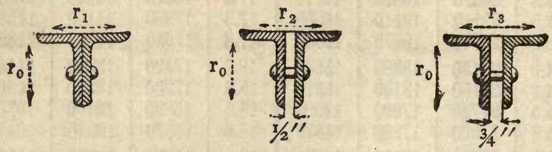
Radii of Gyration given, correspond to directions indicated by arrow-heads.

Neutral axis opposite to arrow.

Size. Inches.	Thickness. Inches.	Weight per foot of single angle Pounds.	RADII OF GYRATION. r_0	r_1	r_2	r_3
6 ×6	$\frac{7}{16}$	17.2	1.87	2.50	2.67	2.76
"	⅞	33.1	1.81	2.57	2.75	2.85
5 ×5	⅜	12.3	1.56	2.09	2.26	2.35
"	⅞	27.2	1.49	2.17	2.35	2.45
4 ×4	⅜	9.8	1.23	1.68	1.86	1.95
"	$\frac{13}{16}$	19.9	1.18	1.75	1.94	2.04
3½×3½	⅜	8.5	1.07	1.47	1.66	1.75
"	$\frac{13}{16}$	17.1	1.02	1.55	1.74	1.85
3 ×3	¼	4.9	0.93	1.25	1.43	1.53
"	⅝	11.4	0.88	1.32	1.51	1.62
2¾×2¾	¼	4.5	0.85	1.15	1.34	1.44
"	½	8.5	0.82	1.19	1.39	1.49
2½×2½	¼	4.1	0.77	1.05	1.24	1.34
"	½	7.7	0.74	1.10	1.29	1.40
2¼×2¼	¼	3.7	0.69	0.96	1.14	1.24
"	½	6.8	0.66	0.99	1.19	1.30

RADII OF GYRATION FOR TWO ANGLES PLACED BACK TO BACK.

ANGLES WITH UNEQUAL LEGS.

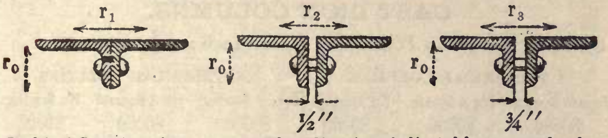


Radii of Gyration given, correspond to directions indicated by arrow-heads.

Size. Inches.	Thickness. Inches.	Weight per foot of single angle Pounds.	RADII OF GYRATION.			
			r_0	r_1	r_2	r_3
7 × 3½	7/16	15.0	2.26	1.21	1.39	1.47
"	1	32.3	2.19	1.31	1.50	1.60
6 × 4	3/8	12.3	1.93	1.50	1.67	1.76
"	7/8	27.2	1.86	1.58	1.76	1.86
6 × 3½	3/8	11.7	1.94	1.26	1.43	1.53
"	7/8	25.7	1.87	1.35	1.54	1.64
5 × 4	3/8	11.0	1.59	1.58	1.75	1.85
"	7/8	24.2	1.52	1.66	1.85	1.95
5 × 3½	3/8	10.4	1.60	1.33	1.51	1.60
"	7/8	22.7	1.53	1.42	1.61	1.71
5 × 3	3/8	9.8	1.61	1.10	1.27	1.37
"	13/16	19.9	1.55	1.18	1.37	1.47
4½ × 3	3/8	9.1	1.44	1.13	1.31	1.41
"	13/16	18.5	1.38	1.25	1.46	1.54
4 × 3½	3/8	9.1	1.25	1.43	1.60	1.70
"	13/16	18.5	1.19	1.50	1.69	1.79
4 × 3	5/16	7.1	1.27	1.17	1.35	1.44
"	13/16	17.1	1.21	1.25	1.45	1.55
3½ × 3	5/16	6.6	1.10	1.22	1.40	1.49
"	13/16	15.7	1.04	1.30	1.50	1.60
3½ × 2½	1/4	4.9	1.12	0.96	1.13	1.23
"	11/16	12.4	1.06	1.03	1.23	1.33
3¼ × 2	1/4	4.3	1.04	0.74	0.92	1.02
"	9/16	9.0	1.00	0.79	0.99	1.10
3 × 2½	1/4	4.5	0.95	1.00	1.18	1.28
"	9/16	9.5	0.91	1.05	1.25	1.35
3 × 2	7/32	3.6	0.96	0.75	0.93	1.03
"	1/2	7.7	0.92	0.80	1.00	1.10
2½ × 2	3/16	2.8	0.79	0.79	0.97	1.07
"	1/2	6.8	0.75	0.84	1.04	1.15

RADII OF GYRATION FOR TWO ANGLES PLACED BACK TO BACK.

ANGLES WITH UNEQUAL LEGS.



Radii of Gyration given, correspond to directions indicated by arrow-heads.

Size. Inches.	Thickness. Inches.	Weight per foot of single angle Pounds.	RADII OF GYRATION.			
			r_0	r_1	r_2	r_3
7 × 3½	7/16	15.0	0.95	3.37	3.56	3.66
"	1	32.3	0.89	3.48	3.68	3.78
6 × 4	3/8	12.3	1.17	2.74	2.92	3.01
"	7/8	27.2	1.11	2.82	3.02	3.12
6 × 3½	3/8	11.7	0.99	2.81	3.00	3.10
"	7/8	25.7	0.93	2.90	3.10	3.20
5 × 4	3/8	11.0	1.20	2.20	2.38	2.48
"	7/8	24.2	1.14	2.29	2.48	2.58
5 × 3½	3/8	10.4	1.02	2.27	2.45	2.55
"	7/8	22.7	0.96	2.36	2.55	2.65
5 × 3	3/8	9.8	0.85	2.35	2.52	2.62
"	13/16	19.9	0.80	2.42	2.62	2.72
4½ × 3	3/8	9.1	0.86	2.07	2.25	2.35
"	13/16	18.5	0.81	2.15	2.35	2.45
4 × 3½	3/8	9.1	1.06	1.74	1.92	2.02
"	13/16	18.5	1.01	1.81	2.01	2.11
4 × 3	5/16	7.1	0.89	1.79	1.97	2.07
"	13/16	17.1	0.83	1.88	2.08	2.18
3½ × 3	5/16	6.6	0.90	1.52	1.71	1.80
"	13/16	15.7	0.85	1.61	1.81	1.91
3½ × 2½	¼	4.9	0.74	1.58	1.76	1.86
"	11/16	12.4	0.67	1.66	1.86	1.96
3¼ × 2	¼	4.3	0.57	1.51	1.70	1.80
"	9/16	9.0	0.53	1.57	1.77	1.88
3 × 2½	¼	4.5	0.75	1.31	1.50	1.59
"	9/16	9.5	0.72	1 37	1.56	1.66
3 × 2	7/32	3.6	0.58	1.38	1.56	1.66
"	½	7.7	0.55	1.42	1.62	1.73
2½ × 2	3/16	2.8	0.60	1.10	1.28	1.39
"	½	6.8	0.56	1.16	1.35	1.46

ULTIMATE STRENGTH OF HOLLOW CYLINDRICAL AND HOLLOW RECTANGULAR CAST IRON COLUMNS.

Ultimate Strength in Pounds per Square Inch:

CYLINDRICAL COLUMNS.

Square Bearing: $\dfrac{80000}{1+\dfrac{(12\,l)^2}{800\,d^2}}$ Pin & Square: $\dfrac{80000}{1+\dfrac{3(12\,l)^2}{1600\,d^2}}$ Pin Bearing: $\dfrac{80000}{1+\dfrac{(12\,l)^2}{400\,d^2}}$

RECTANGULAR COLUMNS.

Square Bearing: $\dfrac{80000}{1+\dfrac{3(12\,l)^2}{3200\,d^2}}$ Pin & Square: $\dfrac{80000}{1+\dfrac{9(12\,l)^2}{6400\,d^2}}$ Pin Bearing: $\dfrac{80000}{1+\dfrac{3(12\,l)^2}{1600\,d^2}}$

l=Length of Column, in feet.
d=External diameter or least side of rectangle, in inches.

$\frac{l}{d}$	CYLINDRICAL COLUMNS. Ultimate Strength in lbs. per sq. in.			RECTANGULAR COLUMNS. Ultimate Strength in lbs. per sq. in.		
	Square Bearing.	Pin and Square.	Pin Bearing.	Square Bearing.	Pin and Square.	Pin Bearing.
1.0	67800	62990	58820	70480	66520	62990
1.1	65690	60300	55730	68790	64260	60300
1.2	63530	57600	52690	67000	61940	57600
1.3	61340	54930	49740	65140	59600	54960
1.4	59140	52310	46900	63260	57270	52320
1.5	56940	49770	44200	61350	54960	49760
1.6	54760	47300	41630	59450	52680	47300
1.7	52620	44940	39210	57550	50460	44960
1.8	50530	42670	36930	55670	48300	42670
1.9	48490	40510	34790	53800	46230	40510
2.0	46510	38460	32790	51940	44200	38460
2.1	44600	36520	30920	50160	42260	36520
2.2	42750	34680	29180	48400	40400	34680
2.3	40980	32940	27540	46670	38630	32950
2.4	39280	31310	26030	44990	36930	31310
2.5	37650	29770	24620	43390	35310	29760
2.6	36090	28320	23300	41820	33770	28320
2.7	34600	26950	22070	40320	32310	26950
2.8	33180	25670	20930	38870	30920	25670
2.9	31820	24460	19860	37470	29600	24460
3.0	30530	23320	18870	36120	28340	23320
3.1	29310	22250	17940	34830	27150	22250
3.2	28140	21250	17070	33580	26030	21250
3.3	27030	20300	16260	32390	24960	20300
3.4	25970	19410	15500	31240	23940	19410

a safety of bet 7 and 8.

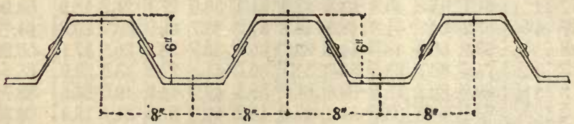
Safe Loads, in Tons of 2,000 Lbs., for Hollow Cylindrical Cast Iron Columns.

Out-side diam., inches	Thickness of Metal.	LENGTH OF COLUMNS, IN FEET. 8 Tons.	10 Tons.	12 Tons.	14 Tons.	16 Tons.	18 Tons.	20 Tons.	22 Tons.	24 Tons.	Sectional Area, inches.	wght., lbs., of columns per foot of length.
6	½	26.2	23.0	20.1	17.5	15.2	13.2	11.5	..	..	8.6	26.95
6	¾	37.5	33.0	28.8	25.0	21.7	18.9	16.5	..	..	12.4	38.59
6	⅞	42.7	37.6	32.8	28.5	24.7	21.5	18.8	..	..	14.1	43.96
6	1	47.6	41.9	36.5	31.8	27.6	24.0	21.0	..	..	15.7	49.01
6	1⅛	52.2	46.0	40.1	34.8	30.2	26.3	23.0	..	..	17.2	53.76
7	¾	47.7	43.1	38.5	34.3	30.4	26.9	23.9	21.2	18.9	14.7	45.96
7	1	61.1	55.2	49.3	43.8	38.9	34.4	30.6	27.1	24.2	18.9	58.90
7	1⅛	67.2	60.8	54.3	48.3	42.8	37.9	33.7	29.9	26.7	20.8	64.77
8	¾	57.9	53.3	48.6	44.1	39.7	35.8	32.2	28.9	26.1	17.1	53.29
8	1	74.6	68.7	62.5	56.7	51.1	46.0	41.4	37.3	33.6	22.0	68.64
8	1¼	89.9	82.8	75.5	68.4	61.7	55.5	49.9	44.9	40.5	26.5	82.71
9	¾	68.1	63.6	58.9	54.2	49.6	45.2	41.2	37.5	34.1	19.4	60.65
9	1	88.0	82.3	76.2	70.0	64.1	58.4	53.2	48.4	44.1	25.1	78.40
9	1¼	106.6	99.6	92.2	84.8	77.6	70.8	64.4	58.7	53.4	30.4	94.94
9	1½	123.8	115.7	107.1	98.5	90.1	82.2	74.8	68.1	62.0	35.3	110.26
9	1¾	139.6	130.5	120.8	111.1	101.6	92.7	84.4	76.8	69.9	39.9	124.36
10	1	101.4	95.9	89.8	83.6	77.4	71.5	65.8	60.5	55.5	28.3	88.23
10	1¼	123.3	116.5	109.1	101.6	94.1	86.8	79.9	73.4	67.5	34.4	107.23
10	1½	143.7	135.8	127.3	118.5	109.7	101.2	93.2	85.6	78.7	40.1	124.99
10	1¾	162.7	153.8	144.1	134.1	124.2	114.6	105.5	97.0	89.1	45.4	141.65
11	1	114.8	109.4	103.5	97.3	91.0	84.8	80.2	73.1	67.7	31.4	98.03
11	1¼	139.9	133.3	126.1	118.6	110.9	103.3	97.8	89.4	82.5	38.3	119.46
11	1½	163.5	155.9	147.5	138.6	128.7	120.8	114.3	104.1	96.4	44.8	139.68
11	1¾	185.7	177.1	167.5	157.5	147.3	137.2	129.8	118.3	109.5	50.9	158.68
11	2	206.6	196.9	186.3	175.1	163.8	152.6	144.4	131.5	121.8	56.6	176.44
12	1	128.0	122.9	117.2	111.0	104.7	98.4	92.2	86.1	80.4	34.6	107.51
12	1¼	156.4	150.1	143.1	135.7	127.9	120.2	112.6	105.2	98.2	42.2	131.41
12	1½	183.3	175.9	167.7	159.0	149.9	140.9	132.0	123.3	115.1	49.5	154.10
12	1¾	208.7	200.4	191.0	181.1	170.7	160.4	150.3	140.5	131.1	56.4	175.53
12	2	232.7	223.4	213.0	201.9	190.4	178.9	167.6	156.6	146.1	62.8	195.75
13	1	141.2	136.3	130.7	124.7	118.5	112.1	105.8	99.5	93.5	37.7	117.53
13	1¼	172.8	166.8	160.0	152.7	145.0	137.2	129.4	121.8	114.4	46.1	143.86
13	1½	203.0	195.9	187.9	179.3	170.3	161.1	152.0	143.1	134.3	54.2	168.98
13	1¾	231.6	223.6	214.5	204.7	194.4	183.9	173.5	163.3	153.3	61.9	192.88
13	2	258.9	249.9	239.7	228.7	217.3	205.5	193.9	182.5	171.3	69.1	215.56
14	1	154.3	149.6	144.3	138.5	132.3	125.9	119.5	113.1	106.8	40.8	127.60
14	1¼	189.2	183.4	176.9	169.7	162.2	154.4	146.5	138.6	131.0	50.1	156.31
14	1½	222.6	215.8	208.1	199.7	190.8	181.7	172.3	163.1	154.1	58.9	183.67
14	1¾	254.4	246.7	237.9	228.3	218.1	207.6	197.0	186.5	176.2	67.4	210.00
14	2	284.8	276.2	266.4	255.6	244.2	232.4	220.6	208.8	197.2	75.4	235.12
15	1	167.4	162.9	157.8	152.1	146.0	139.7	133.3	126.8	120.4	44.0	137.28
15	1¼	205.5	200.0	193.7	186.7	179.3	171.5	163.6	155.7	147.9	54.0	168.48
15	1½	242.1	235.7	228.2	220.0	211.2	202.1	192.8	183.5	174.2	63.6	198.74
15	1¾	277.2	269.8	261.3	251.9	241.9	231.4	220.7	210.1	199.5	72.9	227.45
15	2	310.8	302.5	293.0	282.5	271.2	259.5	247.5	235.5	223.6	81.7	254.90

CORRUGATED FLOORING.

The trough and corrugated plate sections shown on page 31 are used for floors of bridges and fire-proof buildings.

The following tables give weights per lineal foot of each rolled section and per square foot of floor surface for thicknesses varying by $\frac{1}{16}$ inch; also the moments of resistance for one foot in width and the safe loads per square foot for spans of different lengths using fiber strains of 12000 and 10000 lbs.



PROPERTIES OF TROUGH SECTION.

	M10	M11	M12	M13	M14
Section index	M10	M11	M12	M13	M14
Thickness of base	½	$\frac{9}{16}$	⅝	$\frac{11}{16}$	¾
Weight per lineal foot	16.32	18.02	19.72	21.42	23.15
Weight per square foot	25.00	28.15	31.31	34.48	37.74
Moment of resistance	11.56	13.06	14.57	16.12	17.67

SAFE LOADS IN LBS. PER SQUARE FOOT OF FLOOR FOR SPANS OF DIFFERENT LENGTHS.

Span, in Feet.	M10		M11		M12		M13		M14	
	12000 Lbs.	10000 Lbs.	12000 Lbs.	10000 Lbs.	12000 Lbs.	10000 Lbs.	12000 Lbs.	10000 Lbs.	12000 Lbs.	10000 Lbs.
5	3699	3083	4179	3483	4662	3885	5158	4298	5654	4712
6	2569	2141	2902	2418	3238	2698	3582	2985	3927	3272
7	1887	1573	2132	1777	2379	1983	2632	2193	2885	2404
8	1445	1204	1633	1361	1821	1517	2015	1679	2209	1841
9	1142	952	1290	1075	1439	1199	1592	1327	1745	1454
10	925	771	1045	871	1166	972	1290	1075	1414	1178
11	764	637	864	720	963	803	1066	888	1168	973
12	642	535	726	605	809	674	896	747	982	818
13	547	456	618	515	690	575	763	636	836	697
14	472	393	533	444	595	496	658	548	721	601
15	411	343	464	387	518	432	573	478	628	523
16	361	301	408	340	455	379	504	420	552	460

Safe loads given include weight of section.

CORRUGATED FLOORING.

PROPERTIES OF CORRUGATED PLATE.

Section index	M30	M31	M32	M33	M34	M35
Thickness of metal	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$
Weight per lineal foot	8.06	10.10	12.04	17.75	20.71	23.66
Weight per square foot	11.05	13.78	16.50	17.47	20.39	23.30
Moment of resistance	1.10	1.55	1.95	3.28	3.84	4.39

SAFE LOADS IN LBS. PER SQUARE FOOT OF FLOOR.

Span in Feet.	M30		M31.		M32.	
	12000 Lbs.	10000 Lbs.	12000 Lbs.	10000 Lbs.	12000 Lbs.	10000 Lbs.
5	352	293	496	413	624	520
6	244	203	345	287	433	361
7	180	150	253	211	318	265
8	138	115	194	162	244	203
9	109	91	153	128	193	161
10	88	73	124	103	156	130
11	73	61	103	86	129	108
12	61	51	86	72	108	90
13	52	43	73	61	92	77
14	45	38	63	53	80	67
15	39	33	55	46	69	58
16	35	29	49	41	61	51

Span in Feet.	M33		M34		M35	
	12000 Lbs.	10000 Lbs.	12000 Lbs.	10000 Lbs.	12000 Lbs.	10000 Lbs.
5	1049	874	1228	1023	1404	1170
6	728	607	853	711	975	813
7	535	446	627	523	717	598
8	410	342	480	400	549	458
9	324	270	379	316	433	361
10	262	218	307	256	351	293
11	217	181	254	212	290	242
12	182	152	213	178	244	203
13	155	129	182	152	208	173
14	134	112	157	131	179	149
15	117	98	136	113	156	130
16	103	86	120	100	137	114

Safe loads given include weight of section.
Weight per square foot given does not include weight of splice plate.

BUCKLED PLATES.

The old form of Buckled Plate contains one buckle and is square or rectangular, and supported along its four edges in the manner shown by Fig. 2. The central part or buckle is surrounded by a flat rim called the fillet.

A new form of Buckled Plate, made in long lengths, with several buckles to the plate, is shown by Fig. 1, and is manufactured by The Carnegie Steel Company, Limited. In this form the plate is usually supported at the two long edges only.

Buckled plates are used for the floors of fire-proof buildings and of high-way bridges. They are usually covered with concrete or asphalt and stone paving, etc. They are generally made in length and width from 3′ to 4′-6″, and in thicknesses of $\frac{3}{16}$″ to $\frac{3}{8}$″; they are very strong, as indicated by the following table. In order to allow for some deterioration by corrosion, they are, however, rarely made thinner than $\frac{1}{4}$″, while $\frac{5}{16}$″ is a usual thickness for bridge floors.

There has not yet been a reliable formula devised from which the strength of buckled plates can be figured, but from experiments on plates 3′-0″ square, arched $1\frac{3}{4}$″, and well bolted down on all sides, the following table of quiescent safe loads, uniformly distributed, has been deduced.

Thickness.	Weight of one plate, pounds.	Safe Load (one-fourth of ultimate load), pounds.	Per square foot, pounds.
$\frac{3}{16}$″	68	5600	622
$\frac{1}{4}$″	90	10080	1120
$\frac{5}{16}$″	113	13888	1544
$\frac{3}{8}$″	135	20160	2240

The resistance of buckled plates bolted or riveted down all around is double the resistance of the same plate merely supported all around, and if the two opposite sides are unsupported, the resistance is reduced in the proportion of 8 to 5.

STANDARD DIMENSIONS OF BUCKLE PLATES.

DIMENSIONS OF CONTINUOUS BUCKLES. (FIG. 1.)

No. of Plate.	Buckle. e	Buckle. d	Fillets b.	Fillets c.	Fillet a.	Rise f.	No. of Buckles which can be put in one Plate.
1	3′ 11″	4′ 6″	Made from Min.=2″ to Max.=1′ 6″. If longer than 1′ 6″ use angle stiffeners riveted across plate.	Min.=2″. Max.=6″. Try not to exceed 4″.	Preferably made alike. Try not to exceed 4″. Min.=2″. Max.=6″.	3½″	7
2	4′ 6″	3′ 11″				“	6
3	3′ 11″	3′ 6″				3″	7
4	3′ 6″	3′ 11″				“	8
5	3′ 9″	3′ 9″				“	8
6	3′ 1″	3′ 9″				“	9
7	3′ 9″	3′ 1″				“	8
8	3′ 8″	3′ 8″				2″	8
9	2′ 8″	3′ 8″				”	10
10	3′ 8″	2′ 8″				”	8
11	2′ 2″	3′ 8″				”	10
12	3′ 8″	2′ 2″				”	8
13	3′ 0″	3′ 0″				”	9
14	2′ 9″	2′ 9″				3″	10

Plates given above can be made with one buckle or any number up to the limit indicated.

*DIMENSIONS OF SINGLE BUCKLES. (FIG. 2.)

No. of Plate.	Width.	Length.	Fillet a.	Buckle. e	Buckle. d	Rise f.
16	2′ 5¾″	2′ 5¾″	2¼″	2′ 1¼″	2′ 1¼″	2¼″
17	3′ 0″	3′ 0″	“	2′ 7½″	2′ 7½″	2⅝″
18	3′ 4″	3′ 4″	3½″	2′ 9″	2′ 9″	2½″

*No variation from these dimensions can be made.

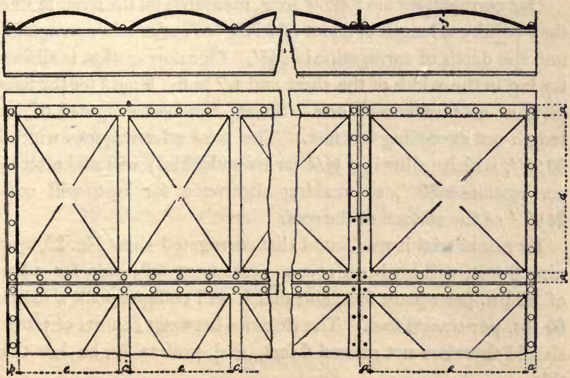


Fig 1 Fig 2

CORRUGATED AND GALVANIZED SHEETS.

Corrugated sheet is used for roofs and sides of buildings. It is usually laid directly upon the purlins in roofs, and held in place by means of clips of hoop iron, which encircle the purlin and are placed in distances of about twelve inches apart. Special care must be taken that the projecting edges of the corrugated sheets, at the eaves and gable ends of the roof, are well secured, otherwise the wind will loosen the sheets and fold them up.

The corrugations are made of various sizes; the smaller present a more pleasing appearance to the eye, while the larger are stiffer and will span a greater distance, thereby permitting the purlins to be placed further apart. The sizes of sheets generally used for both roofing and siding, are Nos. 20 and 22.

The corrugated sheet which will be described in the following, is manufactured by The Carnegie Steel Company, Limited. It is of medium size, presenting both a good appearance and being of sufficient strength for usual requirements.

By one corrugation is meant the double curve between corresponding points, and by depth of corrugation the greatest deviation from the straight line measured between the concave surfaces of the corrugated sheet.

Our corrugations are 2.425″ long, measured on the straight line; they require a length of sheet of 2.725″ to make one corrugation, and the depth of corrugation is $\frac{21}{32}$″. One corrugation is allowed for lap in the width of the sheet and 6″ in the length for the usual pitch of roof of two to one. Sheets can be corrugated of any length not exceeding ten feet. The most advantageous width is 30½″, which (allowing ½″ for irregularities) will make eleven corrugations=30″, or, making allowance for laps, will cover 24¼″ of the surface of the roof.

By actual trial it was found that corrugated sheet No. 20, spanning 6 feet, will begin to give a permanent deflection for a load of 30 lbs. per square foot, and that it will collapse with a load of 60 lbs. per square foot. The distance between centers of purlins should therefore not exceed 6 feet, and, preferably, be less than this.

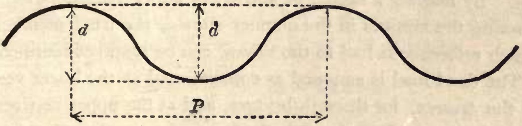
CORRUGATED SHEETS.

The following table is calculated for sheets 30½″ wide before corrugating.

No. by Birmingham Gauge.	Thickness. Inch.	Weight per Square Foot, Flat. Lbs.	Weight per Square Foot, Corrugated. Lbs.	Weight per Square of 100 square feet, when laid, allowing 6″ lap in length and 2½″ or one corrugation in width of sheet, for sheet lengths of: 5′	6′	7′	8′	9′	10′	Weight per Square Foot, Flat, Galvanized. Lbs.
16	.065	2.61	3.28	365	358	353	350	348	346	2.95
18	.049	1.97	2.48	275	270	267	264	262	261	2.31
20	.035	1.40	1.76	196	192	190	188	186	185	1.74
22	.028	1.12	1.41	156	154	152	150	149	148	1.46
24	.022	.88	1.11	123	121	119	118	117	117	1.22
26	.018	.72	.91	101	99	97	97	96	95	1.06

NOTE.—For weights per square laid with one and one-half lap, add to above 5 per cent. For weights per square laid with two laps, add to above 10 per cent.

TRANSVERSE STRENGTH.



l=Unsupported length of sheet, in inches.
t=Thickness of sheet, in inches.
b=Width of sheet, in inches.
d=Depth of corrugations in inches.
W=Breaking weight distributed in tons.
w= " " " " pounds.

$$W = \frac{49.95\ t.b.d.}{l}$$

$$w = \frac{99900\ t.b.d.}{l}$$

EXPLANATION OF TABLES ON MAXIMUM STRESSES IN PRATT AND WHIPPLE TRUSSES.

Pages 163 to 165.

These tables give the stress in each member of a Pratt (single quadrangular) or Whipple (double quadrangular) truss, for any number of panels not exceeding twelve in the former, and twenty in the latter case, on the assumption that the load is uniform per foot, and the panels are all of the same length. The stresses are given in terms of the truss-panel dead and moving loads, represented respectively by W. and L. These are obtained by multiplying the dead load per foot of bridge, in the case of W, and the moving or live load per foot of bridge, in the case of L, by half the panel length.

The letters W and L are placed at the top of column in tables, and not next to the figures to which they belong, for want of space.

The stress in aB, for example, in a twelve panel Pratt truss, $= 5.5$ W $+ 5.5$ L, and in Bc $= 4.5$ W $+ \frac{55}{12}$ L, both multiplied by the quotient specified in the last column.

The system of lettering employed is shown by Figs. 1 and 2, on page 162, opposite, and, it is believed, is the best in use. By making a sketch of the truss under consideration and lettering the vertices in the manner shown, the truss members to which reference is had in the tables, can be readily identified.

The dead load is assumed as concentrated at the lower vertices of the trusses, for through bridges, and at the upper vertices, for deck bridges. For through bridges of very large span, the stresses thus obtained for the posts must be increased by the truss-panel weight of the upper portion of the truss, including the lateral bracing; but in small spans, the increase of stress on this account is so inconsiderable that it is usually neglected.

Note: In order to calculate the stresses in a Whipple or double quadrangular truss by statical methods, it is necessary to consider the truss as the combination of two Pratt trusses or single systems of bracing, and assume that each of these two systems is strained in the same manner as if one were independent of the other. If the number of panels is odd, each of the two systems is unsymmetrical, which has the effect of making the stress in the middle panel of the lower chord slightly smaller than the stress in the

corresponding panel of the top chord. The difference is, however, frequently neglected, and the stress in middle panel of bottom chord assumed the same as in middle panel of top chord.

Each of the two systems is assumed to carry one-half of the panel load at the top of the inclined end posts.

Fig. 1
Pratt or Single Quadrangular Truss.

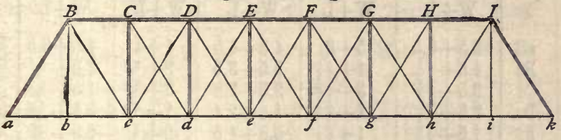


Fig. 2
Whipple or Double Quadrangular Truss.

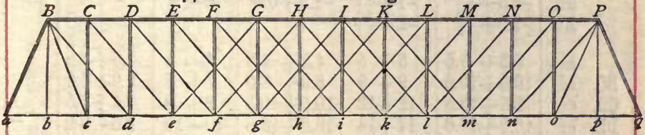


Illustration of Application of Tables, also of the Use of Table of Natural Sines, Tangents and Secants.

A Pratt truss of 135′ span and 18′ depth, is divided into nine panels of 15′ each. Required the stress in first main tie Bc, and in middle panel DE of top chord, for a dead load of 1200 lbs., and a moving load of 3000 lbs. per lineal foot of bridge.

$$W = \frac{1200}{2} \times 15 = 9000 \text{ lbs.}$$

$$L = \frac{3000}{2} \times 15 = 22500 \text{ lbs.}$$

$$Bc = (3\,W + \frac{28}{9}\,L) \times \frac{\text{Length Bc}}{18}$$

$$DE = (10\,W + 10\,L)\,\frac{15}{18}$$

The factor $\frac{15}{18}$, or panel length divided by depth of truss, is the tangent of the angle, for which the length Bc, divided by depth of truss, is the secant. By table of natural sines, tangents and secants, for tangent $= \frac{15}{18} = 0.833$, the secant $= 1.302$; therefore :—

$$Bc = 97000 \times 1.30 = 126100 \text{ lbs.}$$

$$DE = 315000 \times \frac{15}{18} = 262500 \text{ lbs.}$$

MAXIMUM STRESSES UNDER DEAD AND MOVING LOADS IN PRATT OR SINGLE QUADRANGULAR TRUSSES

With inclined end posts and equal panels, for Through and Deck Bridges.
W = dead load and L = moving load per truss and per panel.

Member.	12 Panel Truss. W+L	11 Panel Truss. W+L	10 Panel Truss. W+L	9 Panel Truss. W+L	8 Panel Truss. W+L	Multiply by:
aB	5.5+5.5	5+5	4.5+4.5	4+4	3.5+3.5	Length of member divided by depth of truss.
Bc	4.5+$\frac{55}{12}$	4+$\frac{45}{11}$	3.5+3.6	3+$\frac{28}{9}$	2.5+$\frac{21}{8}$	
Cd	3.5+$\frac{45}{12}$	3+$\frac{36}{11}$	2.5+2.8	2+$\frac{21}{9}$	1.5+$\frac{15}{8}$	
De	2.5+$\frac{36}{12}$	2+$\frac{28}{11}$	1.5+2.1	1+$\frac{15}{9}$	0.5+$\frac{10}{8}$	
Ef	1.5+$\frac{28}{12}$	1+$\frac{21}{11}$	0.5+1.5	0+$\frac{10}{9}$	−0.5+$\frac{6}{8}$	
Fg	0.5+$\frac{21}{12}$	0+$\frac{15}{11}$	−0.5+1.0	−1+$\frac{6}{9}$	−1.5+$\frac{3}{8}$	
Gh	−0.5+$\frac{15}{12}$	−1+$\frac{10}{11}$	−1.5+0.6	−2+$\frac{3}{9}$		
Hi	−1.5+$\frac{10}{12}$	−2+$\frac{6}{11}$				
abc	5.5+ 5.5	5+ 5	4.5+ 4.5	4+ 4	3.5+3.5	Panel length divided by depth of truss.
BC, cd	10.0+10.0	9+ 9	8.0+ 8.0	7+ 7	6.0+6.0	
CD, de	13.5+13.5	12+12	10.5+10.5	9+ 9	7.5+7.5	
DE, ef	16.0+16.0	14+14	12.0+12.0	10+10	8.0+8.0	
EF, fg	17.5+17.5	15+15	12.5+12.5			
FG	18.0+18.0					
Thro'. Deck.						
Cc	4.5+$\frac{55}{12}$	4+$\frac{45}{11}$	3.5+3.6	3+$\frac{28}{9}$	2.5+$\frac{21}{8}$	Unity.
Cc, Dd	3.5+$\frac{45}{12}$	3+$\frac{36}{11}$	2.5+2.8	2+$\frac{21}{9}$	1.5+$\frac{15}{8}$	
Dd, Ee	2.5+$\frac{36}{12}$	2+$\frac{28}{11}$	1.5+2.1	1+$\frac{15}{9}$	0.5+$\frac{10}{8}$	
Ee, Ff	1.5+$\frac{28}{12}$	1+$\frac{21}{11}$	0.5+1.5	0+$\frac{10}{9}$	−0.5+$\frac{6}{8}$	
Ff, Gg	0.5+$\frac{21}{12}$	0+$\frac{15}{11}$	−0.5+1.0			
Gg	−0.5+$\frac{15}{12}$					

Member.	7 Panel Truss. W+L	6 Panel Truss. W+L	5 Panel Truss. W+L	4 Panel Truss. W+L	3 Panel Truss. W+L	Multiply by:
aB	3+3	2.5+2.5	2+2.0	1.5+1.5	1+1	Length of member divided by depth of truss.
Bc	2+$\frac{15}{7}$	1.5+$\frac{10}{6}$	1+1.2	0.5+$\frac{3}{4}$	0+$\frac{1}{3}$	
Cd	1+$\frac{10}{7}$	0.5+1.0	0+0.6	−0.5+$\frac{1}{4}$		
De	0+$\frac{6}{7}$	−0.5+0.5	−1+0.2			
Ef	−1+$\frac{3}{7}$					
abc	3+3	2.5+2.5	2+2	1.5+1.5	1+1	Panel Length divided by depth of truss.
BC, cd	5+5	4.0+4.0	3+3	2.0+2.0	1+1	
CDE, de	6+6	4.5+4.5				
Thro'. Deck.						
Cc	2+$\frac{15}{7}$	1.5+$\frac{10}{6}$	1+1.2	0.5+$\frac{3}{4}$		Unity.
Cc, Dd	1+$\frac{10}{7}$	0.5+1.0	0+0.6	−0.5+$\frac{1}{4}$		
Dd	0+$\frac{6}{7}$	−0.5+0.5				

MAXIMUM STRESSES UNDER DEAD AND MOVING LOADS IN WHIPPLE OR DOUBLE QUADRANGULAR TRUSSES

With inclined end posts and equal panels, for Through and Deck Bridges.

W = dead load and L = moving load per truss and per panel.

Member.	20 Panel Truss.	19 Panel Truss.	18 Panel Truss.	17 Panel Truss.	16 Panel Truss.	Multiply by:
	W+L	W+L	W+L	W+L	W+L	
aB	$9.5+9.5$	$9+9$	$8.5+8.5$	$8+8$	$7.5+7.5$	Length of member divided by depth of truss.
Bc	$4.5+\frac{90.5}{20}$	$\frac{80}{19}+\frac{80.5}{19}$	$4.0+\frac{72.5}{18}$	$\frac{63}{17}+\frac{63.5}{17}$	$3.5+\frac{56.5}{16}$	
Bd	$4.0+\frac{80.5}{20}$	$\frac{72}{19}+\frac{72.5}{19}$	$3.5+\frac{63.5}{18}$	$\frac{56}{17}+\frac{56.5}{17}$	$3.0+\frac{48.5}{16}$	
Ce	$3.5+\frac{72.5}{20}$	$\frac{61}{19}+\frac{63.5}{19}$	$3.0+\frac{56.5}{18}$	$\frac{46}{17}+\frac{48.5}{17}$	$2.5+\frac{42.5}{16}$	
Df	$3.0+\frac{63.5}{20}$	$\frac{53}{19}+\frac{56.5}{19}$	$2.5+\frac{48.5}{18}$	$\frac{39}{17}+\frac{42.5}{17}$	$2.0+\frac{35.5}{16}$	
Eg	$2.5+\frac{56.5}{20}$	$\frac{42}{19}+\frac{48.5}{19}$	$2.0+\frac{42.5}{18}$	$\frac{29}{17}+\frac{35.5}{17}$	$1.5+\frac{30.5}{16}$	
Fh	$2.0+\frac{48.5}{20}$	$\frac{34}{19}+\frac{42.5}{19}$	$1.5+\frac{35.5}{18}$	$\frac{22}{17}+\frac{30.5}{17}$	$1.0+\frac{24.5}{16}$	
Gi	$1.5+\frac{42.5}{20}$	$\frac{23}{19}+\frac{35.5}{19}$	$1.0+\frac{30.5}{18}$	$\frac{12}{17}+\frac{24.5}{17}$	$0.5+\frac{20.5}{16}$	
Hk	$1.0+\frac{35.5}{20}$	$\frac{15}{19}+\frac{30.5}{19}$	$0.5+\frac{24.5}{18}$	$\frac{5}{17}+\frac{20.5}{17}$	$0.0+\frac{15.5}{16}$	
Il	$0.5+\frac{30.5}{20}$	$\frac{4}{19}+\frac{24.5}{19}$	$0.0+\frac{20.5}{18}$	$-\frac{5}{17}+\frac{15.5}{17}$	$-0.5+\frac{12.5}{16}$	
Km	$0.0+\frac{24.5}{20}$	$-\frac{4}{19}+\frac{20.5}{19}$	$-0.5+\frac{15.5}{18}$	$-\frac{12}{17}+\frac{12.5}{17}$	$-1.0+\frac{8.5}{16}$	
Ln	$-0.5+\frac{20.5}{20}$	$-\frac{15}{19}+\frac{15.5}{19}$	$-1.0+\frac{12.5}{18}$	$-\frac{22}{17}+\frac{8.5}{17}$	$-1.5+\frac{6.5}{16}$	
Mo	$-1.0+\frac{15.5}{20}$	$-\frac{23}{19}+\frac{12.5}{19}$				
abc	$9.5+9.5$	$9+9$	$8.5+8.5$	$8+8$	$7.5+7.5$	Panel length divided by depth of truss.
cd	$14+14$	$\frac{251}{19}+\frac{251}{19}$	$12.5+12.5$	$\frac{199}{17}+\frac{199}{17}$	$11+11$	
BC, de	$22+22$	$\frac{395}{19}+\frac{395}{19}$	$19.5+19.5$	$\frac{311}{17}+\frac{311}{17}$	$17+17$	
CD, ef	$29+29$	$\frac{517}{19}+\frac{517}{19}$	$25.5+25.5$	$\frac{403}{17}+\frac{403}{17}$	$22+22$	
DE, fg	$35+35$	$\frac{623}{19}+\frac{623}{19}$	$30.5+30.5$	$\frac{481}{17}+\frac{481}{17}$	$26+26$	
EF, gh	$40+40$	$\frac{707}{19}+\frac{707}{19}$	$34.5+34.5$	$\frac{539}{17}+\frac{539}{17}$	$29+29$	
FG, hi	$44+44$	$\frac{775}{19}+\frac{775}{19}$	$37.5+37.5$	$\frac{583}{17}+\frac{583}{17}$	$31+31$	
GH, ik	$47+47$	$\frac{821}{19}+\frac{821}{19}$	$39.5+39.5$	$\frac{607}{17}+\frac{607}{17}$*	$32+32$	
HI, kl	$49+49$	$\frac{851}{19}+\frac{851}{19}$*	$40.5+40.5$	$\frac{617}{17}+\frac{617}{17}$	HI=GH	
IKL	$50+50$	$\frac{859}{19}+\frac{859}{19}$	IK=HI	IK=HI		
		*kl= $\frac{843}{19}+\frac{843}{19}$		*ik= $\frac{597}{17}+\frac{597}{17}$		
Thro'. Deck.						
Cc	$4.5+\frac{90.5}{20}$	$\frac{80}{19}+\frac{80.5}{19}$	$4.0+\frac{72.5}{18}$	$\frac{63}{17}+\frac{63.5}{17}$	$3.5+\frac{56.5}{16}$	Unity.
Dd	$4.0+\frac{80.5}{20}$	$\frac{72}{19}+\frac{72.5}{19}$	$3.5+\frac{63.5}{18}$	$\frac{56}{17}+\frac{56.5}{17}$	$3.0+\frac{48.5}{16}$	
Cc, Ee	$3.5+\frac{72.5}{20}$	$\frac{61}{19}+\frac{63.5}{19}$	$3.0+\frac{56.5}{18}$	$\frac{46}{17}+\frac{48.5}{17}$	$2.5+\frac{42.5}{16}$	
Dd, Ff	$3.0+\frac{63.5}{20}$	$\frac{53}{19}+\frac{56.5}{19}$	$2.5+\frac{48.5}{18}$	$\frac{39}{17}+\frac{42.5}{17}$	$2.0+\frac{35.5}{16}$	
Ee, Gg	$2.5+\frac{56.5}{20}$	$\frac{42}{19}+\frac{48.5}{19}$	$2.0+\frac{42.5}{18}$	$\frac{29}{17}+\frac{35.5}{17}$	$1.5+\frac{30.5}{16}$	
Ff, Hh	$2.0+\frac{48.5}{20}$	$\frac{34}{19}+\frac{42.5}{19}$	$1.5+\frac{35.5}{18}$	$\frac{22}{17}+\frac{30.5}{17}$	$1.0+\frac{24.5}{16}$	
Gg, Ii	$1.5+\frac{42.5}{20}$	$\frac{23}{19}+\frac{35.5}{19}$	$1.0+\frac{30.5}{18}$	$\frac{12}{17}+\frac{24.5}{17}$	$0.5+\frac{20.5}{16}$	
Hh, Kk	$1.0+\frac{35.5}{20}$	$\frac{15}{19}+\frac{30.5}{19}$	$0.5+\frac{24.5}{18}$	$\frac{5}{17}+\frac{20.5}{17}$	$0.0+\frac{15.5}{16}$	
Ii, Ll	$0.5+\frac{30.5}{20}$	$\frac{4}{19}+\frac{24.5}{19}$	$0.0+\frac{20.5}{18}$	$-\frac{5}{17}+\frac{15.5}{17}$	$-0.5+\frac{12.5}{16}$	
Kk	$0.0+\frac{24.5}{20}$	$-\frac{4}{19}+\frac{20.5}{19}$	$-0.5+\frac{15.5}{18}$			
Ll	$-0.5+\frac{20.5}{20}$					

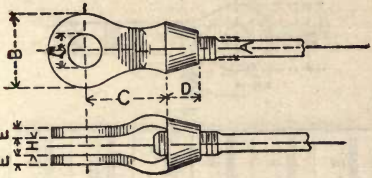
MAXIMUM STRESSES UNDER DEAD AND MOVING LOADS IN WHIPPLE OR DOUBLE QUADRANGULAR TRUSSES

With inclined end posts and equal panels, for Through and Deck Bridges.

W = dead load and L = moving load per truss and per panel.

Member.	15 Panel Truss.	14 Panel Truss.	13 Panel Truss.	12 Panel Truss.	11 Panel Truss.	Multiply by:
	W+L	W+L	W+L	W+L	W+L	
aB	7+7	6.5+6.5	6+6	5.5+5.5	5+5	Length of member divided by depth of truss.
Bc	$\frac{48}{15}+\frac{48.5}{15}$	$3.0+\frac{42.5}{14}$	$\frac{35}{13}+\frac{35.5}{13}$	$2.5+\frac{30.5}{12}$	$\frac{24}{11}+\frac{24.5}{11}$	
Bd	$\frac{42}{15}+\frac{42.5}{15}$	$2.5+\frac{35.5}{14}$	$\frac{30}{13}+\frac{30.5}{13}$	$2.0+\frac{24.5}{12}$	$\frac{20}{11}+\frac{20.5}{11}$	
Ce	$\frac{33}{15}+\frac{35.5}{15}$	$2.0+\frac{30.5}{14}$	$\frac{22}{13}+\frac{24.5}{13}$	$1.5+\frac{20.5}{12}$	$\frac{13}{11}+\frac{15.5}{11}$	
Df	$\frac{27}{15}+\frac{30.5}{15}$	$1.5+\frac{24.5}{14}$	$\frac{17}{13}+\frac{20.5}{13}$	$1.0+\frac{15.5}{12}$	$\frac{9}{11}+\frac{12.5}{11}$	
Eg	$\frac{18}{15}+\frac{24.5}{15}$	$1.0+\frac{20.5}{14}$	$\frac{9}{13}+\frac{15.5}{13}$	$0.5+\frac{12.5}{12}$	$\frac{2}{11}+\frac{8.5}{11}$	
Fh	$\frac{12}{15}+\frac{20.5}{15}$	$0.5+\frac{15.5}{14}$	$\frac{4}{13}+\frac{12.5}{13}$	$0.0+\frac{8.5}{12}$	$-\frac{2}{11}+\frac{6.5}{11}$	
Gi	$\frac{3}{15}+\frac{15.5}{15}$	$0.0+\frac{12.5}{14}$	$-\frac{4}{13}+\frac{8.5}{13}$	$-0.5+\frac{6.5}{12}$	$-\frac{9}{11}+\frac{3.5}{11}$	
Hk	$-\frac{3}{15}+\frac{12.5}{15}$	$-0.5+\frac{8.5}{14}$	$-\frac{9}{13}+\frac{6.5}{13}$	$-1.0+\frac{3.5}{12}$	$-\frac{13}{11}+\frac{2.5}{11}$	
Il	$-\frac{12}{15}+\frac{8.5}{15}$	$-1.0+\frac{6.5}{14}$	$-\frac{17}{13}+\frac{3.5}{13}$			
Km	$-\frac{18}{15}+\frac{6.5}{15}$					
abc	7+7	6.5+ 6.5	6+6	5.5+ 5.5	5+5	Panel length divided by depth of truss.
cd	$\frac{153}{15}+\frac{153}{15}$	9.5+ 9.5	$\frac{113}{13}+\frac{113}{13}$	8.0+ 8.0	$\frac{79}{11}+\frac{79}{11}$	
BC, de	$\frac{237}{15}+\frac{237}{15}$	14.5+14.5	$\frac{173}{13}+\frac{173}{13}$	12.0+12.0	$\frac{119}{11}+\frac{119}{11}$	
CD, ef	$\frac{303}{15}+\frac{303}{15}$	18.5+18.5	$\frac{217}{13}+\frac{217}{13}$	15.0+15.0	$\frac{145}{11}+\frac{145}{11}$	
DE, fg	$\frac{357}{15}+\frac{357}{15}$	21.5+21.5	$\frac{251}{13}+\frac{251}{13}$	17.0+17.0	$\frac{163}{11}+\frac{163}{11}$*	
EF, gh	$\frac{393}{15}+\frac{393}{15}$	23.5+23.5	$\frac{269}{13}+\frac{269}{13}$*	18.0+18.0	$\frac{167}{11}+\frac{167}{11}$	
FG, hi	$\frac{417}{15}+\frac{417}{15}$*	24.5+24.5	$\frac{277}{13}+\frac{277}{13}$	FG=EF	FG=EF	
GHI	$\frac{423}{15}+\frac{423}{15}$	GH=FG	GH=FG		*fg= $\frac{159}{11}+\frac{159}{11}$	
	*hi= $\frac{411}{15}+\frac{411}{15}$		*gh= $\frac{261}{13}+\frac{261}{13}$			
Thro'. Deck.						
Cc	$\frac{48}{15}+\frac{48.5}{15}$	$3.0+\frac{42.5}{14}$	$\frac{35}{13}+\frac{35.5}{13}$	$2.5+\frac{30.5}{12}$	$\frac{24}{11}+\frac{24.5}{11}$	Unity.
Dd	$\frac{42}{15}+\frac{42.5}{15}$	$2.5+\frac{35.5}{14}$	$\frac{30}{13}+\frac{30.5}{13}$	$2.0+\frac{24.5}{12}$	$\frac{20}{11}+\frac{20.5}{11}$	
Cc, Ee	$\frac{33}{15}+\frac{35.5}{15}$	$2.0+\frac{30.5}{14}$	$\frac{22}{13}+\frac{24.5}{13}$	$1.5+\frac{20.5}{12}$	$\frac{13}{11}+\frac{15.5}{11}$	
Dd, Ff	$\frac{27}{15}+\frac{30.5}{15}$	$1.5+\frac{24.5}{14}$	$\frac{17}{13}+\frac{20.5}{13}$	$1.0+\frac{15.5}{12}$	$\frac{9}{11}+\frac{12.5}{11}$	
Ee, Gg	$\frac{18}{15}+\frac{24.5}{15}$	$1.0+\frac{20.5}{14}$	$\frac{9}{13}+\frac{15.5}{13}$	$0.5+\frac{12.5}{12}$	$\frac{2}{11}+\frac{8.5}{11}$	
Ff, Hh	$\frac{12}{15}+\frac{20.5}{15}$	$0.5+\frac{15.5}{14}$	$\frac{4}{13}+\frac{12.5}{13}$	$0.0+\frac{8.5}{12}$	$-\frac{2}{11}+\frac{6.5}{11}$	
Gg	$\frac{3}{15}+\frac{15.5}{15}$	$0.0+\frac{12.5}{14}$	$-\frac{4}{13}+\frac{8.5}{13}$	$-0.5+\frac{6.5}{12}$		
Hh	$-\frac{3}{15}+\frac{12.5}{15}$	$-0.5+\frac{8.5}{14}$				

STANDARD CLEVIS NUTS.



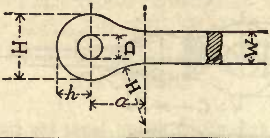
Distance H can be made to suit connections.

Diameter of Round Bar.	A Upset Screw End for Round Bar.	Side of Square Bar.	A Upset Screw End for Square Bar.	B Diameter of Eye.	C Length of Fork.	D Length of Thread.	E Thickness of Bar in Fork.	F Width of Bar in Fork.	G Diameter of Pin.
1¼*	1⅝	1⅛	1⅝	4¾	5½	2	⅝	2½	1⅞
1 5/16	1¾	1 3/16	1¾	5⅞	6½	2½	¾	3 3/16	2¼
1⅜	1¾	1¼	1⅞	5⅞	6½	2½	¾	3 3/16	2¼
1 7/16	1⅞	1 5/16	1⅞	5⅞	6½	2½	¾	3 3/16	2¼
1½	2	1⅜	2	5⅞	6½	2½	¾	3 3/16	2¼
1 9/16	2	1 7/16	2⅛	5⅞	6½	2½	¾	3 3/16	2¼
1⅝	2⅛	. .		5⅞	6½	2½	¾	3 3/16	2¼
1 11/16	2⅛	1½	2⅛	6⅝	7	2⅞	⅞	3 9/16	2⅝
1¾	2¼	1 9/16	2¼	6⅝	7	2⅞	⅞	3 9/16	2⅝
1 13/16	2¼	1⅝	2⅜	6⅝	7	2⅞	⅞	3 9/16	2⅝
1⅞	2⅜	1 11/16	2⅜	6⅝	7	2⅞	⅞	3 9/16	2⅝
1 15/16	2½	1¾	2½	7⅞	8	3½	1⅛	3⅞	3⅛
2	2½	1 13/16	2⅝	7⅞	8	3½	1⅛	3⅞	3⅛
2 1/16	2⅝	1⅞	2⅝	7⅞	8	3½	1⅛	3⅞	3⅛
2⅛	2⅝	1 15/16	2¾	7⅞	8	3½	1⅛	3⅞	3⅛
2 3/16	2¾	2	2⅞	7⅞	8	3½	1⅛	3⅞	3⅛
2¼	2⅞	. .	.	7⅞	8	3½	1⅛	3⅞	3⅛
2 5/16	2⅞	2 1/16	2⅞	9	8½	4	1¼	4 13/16	3⅝
2⅜	3	2⅛	3	9	8½	4	1¼	4 13/16	3⅝
2 7/16	3⅛	2 3/16	3⅛	9	8½	4	1¼	4 13/16	3⅝
2½	3⅛	2¼	3⅛	9	8½	4	1¼	4 13/16	3⅝
2 9/16	3¼	2 5/16	3¼	9	8½	4	1¼	4 13/16	3⅝
2⅝	3¼	2⅜	3⅜	9	8½	4	1¼	4 13/16	3⅝
2 11/16	3⅜	.	.	9	8½	4	1¼	4 13/16	3⅝
2¾	3⅜	2 7/16	3⅜	9¾	9	4¼	1⅝	5¼	3⅞
2 13/16	3½	2½	3½	9¾	9	4¼	1⅝	5¼	3⅞
2⅞	3⅝	2 9/16	3⅝	9¾	9	4¼	1⅝	5¼	3⅞
2 15/16	3⅝	2⅝	3⅝	9¾	9	4¼	1⅝	5¼	3⅞

* This Clevis used for all smaller Bars.

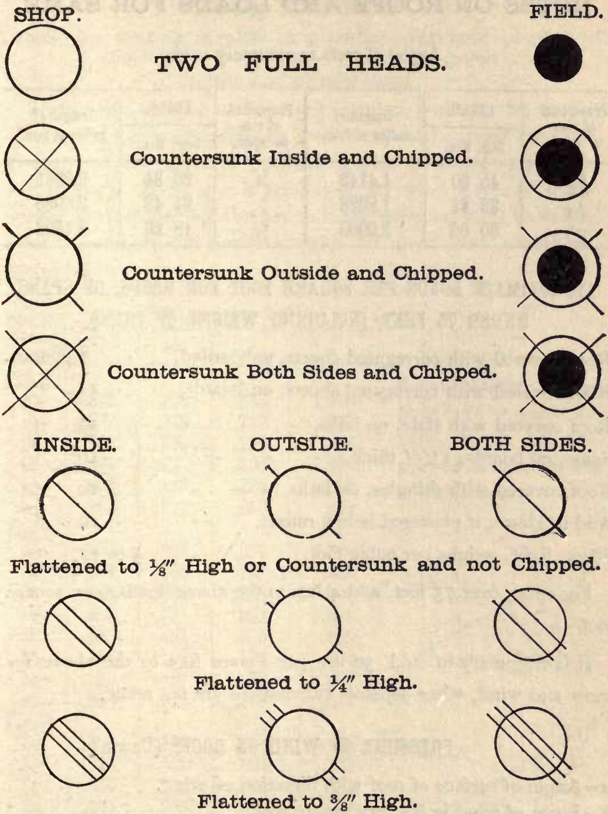
STANDARD EYE BAR HEADS.

SIZES IN INCHES.



Width of Bar "W."	Diameter of Pin "D"	Distance "H"	Distance "h"	Distance "a"	Width of Bar "W"	Diameter of Pin "D"	Distance "H"	Distance "h"	Distance "a"
3	2½	7	3½	6⅛	6	8	17	8½	15⅞
3	3	7½	3¾	6¾	7	4½	15	7½	12⅞
3	3½	8	4	7⅜	7	5	15½	7¾	13⅜
3	4	8½	4¼	7⅞	7	5½	16	8	14
3	4½	9	4½	8½	7	6	16½	8¼	14½
3	5	9½	4¾	9	7	6½	17	8½	15⅛
3	5½	10	5	9⅝	7	7	17½	8¾	15¾
3	6	10½	5¼	10¼	7	7½	18	9	16⅜
3	6½	11	5½	10¾	7	8	18½	9¼	17
3	7	11½	5¾	11⅜	7	8½	19	9½	17⅝
4	3	9	4½	7 13/16	7	9	19½	9¾	18 11/16
4	3½	9½	4¾	8⅜	8	5	17	8½	14⅜
4	4	10	5	9	8	5½	17½	8¾	15
4	4½	10½	5¼	9 9/16	8	6	18	9	15⅝
4	5	11	5½	10⅛	8	6½	18½	9¼	16¼
4	5½	11½	5¾	10¾	8	7	19	9½	16⅞
4	6	12	6	11⅜	8	7½	19½	9¾	17½
4	6½	12½	6¼	11 15/16	8	8	20	10	18
4	7	13	6½	12½	8	8½	20½	10¼	18½
5	3½	11	5½	9½	8	9	21	10½	19⅛
5	4	11½	5¾	10	8	9½	21½	10¾	19¾
5	4½	12	6	10⅝	8	10	22	11	20⅜
5	5	12½	6¼	11¼	9	6	19½	9¾	16¾
5	5½	13	6½	11⅞	9	6½	20	10	17 5/16
5	6	13½	6¾	12⅜	9	7	20½	10¼	17⅞
5	6½	14	7	13	9	7½	21	10½	18½
5	7	14½	7¼	13½	9	8	21½	10¾	19 1/16
5	7½	15	7½	14⅛	9	8½	22	11	19 11/16
6	4	13	6½	11⅛	9	9	22½	11¼	20¼
6	4½	13½	6¾	11¾	9	9½	23	11½	20 13/16
6	5	14	7	12⅜	9	10	23½	11¾	21⅜
6	5½	14½	7¼	13	10	7½	22½	11¼	19 9/16
6	6	15	7½	13½	10	8	23	11½	20 1/16
6	6½	15½	7¾	14	10	8½	23½	11¾	20 11/16
6	7	16	8	14⅝	10	9	24	12	21 5/16
6	7½	16½	8¼	15¼	. .	. .	. .	. .	. .

CONVENTIONAL SIGNS FOR RIVETING.



This system, as designed by F. C. Osborne, C. E., has for foundation the diagonal cross to represent a countersink, the blackened circle for a field rivet, and the vertical stroke to indicate a flattened head. The position of the cross, with respect to the circle (inside, outside, or both sides), indicates the location of the countersink, and the number and position of the vertical strokes indicate the height and position of the flattened heads.

Any combination of field, countersunk and flattened head rivets liable to occur may be readily indicated by the proper combination of above signs.

NOTES ON ROOFS AND LOADS FOR SAME.

Angles of roofs as commonly used.

Proportion of rise to span.	ANGLE. Deg. Min.	Length of rafter to rise.	Proportion of rise to span.	ANGLE. Deg. Min.	Length of rafter to rise.
$\frac{1}{2}$	45 00	1.4142	$\frac{1}{4}$	26 34	2.2361
$\frac{1}{3}$	33 41	1.8028	$\frac{1}{5}$	21 48	2.6926
$\frac{1}{2\sqrt{3}}$	30 00	2.0000	$\frac{1}{6}$	18 26	3.1623

APPROXIMATE LOADS PER SQUARE FOOT FOR ROOFS, OF SPANS UNDER 75 FEET, INCLUDING WEIGHT OF TRUSS.

Roof covered with corrugated sheets, unboarded,	8	pounds.
Roof covered with corrugated sheets, on boards,	11	"
Roof covered with slate, on laths,	13	"
Same, on boards, $1\frac{1}{4}''$ thick,	16	"
Roof covered with shingles, on laths,	10	"
Add to above, if plastered below rafters,	10	"
Snow, light, weighs per cubic foot,	5 to 12	"

For spans over 75 feet, add 4 lbs. to the above loads, per square foot.

It is customary to add 30 lbs. per square foot to the above for snow and wind, when separate calculations are not made.

PRESSURE OF WIND ON ROOFS. (Unwin)

a = Angle of surface of roof with direction of wind.
F = Force of wind in lbs. per square foot.
A = Pressure normal to surface of roof = $F \text{ Sin. } a^{1.84 \text{ Cos. } a - 1}$.
B = Pressure perpendicular to direction of wind = $F \text{ Cot. } a \text{ Sin } a^{1.84 \text{ Cos. } a}$.
C = Pressure parallel to direction of wind = $F \text{ Sin. } a^{1.84 \text{ Cos. } a}$.

Angle of roof = a	5°	10°	20°	30°	40°	50°	60°	70°	80°	90°
A = F ×	.125	.24	.45	.66	.83	.95	1.00	1.02	1.01	1.00
B = F ×	.122	.24	.42	.57	.64	.61	.50	.35	.17	.00
C = F ×	.01	.04	.15	.33	.53	.73	.85	.96	.99	1.00

ROOF TRUSSES.

Tables for finding strains in members for roof trusses of the different types and pitches as given below and of any span.

RULE.—To find the strain in any member, multiply the coefficient given for that member by total dead load carried by truss (=span in feet × distance between trusses in feet × weight per square foot). If the truss is acted upon by wind forces or other unsymmetrical loading the strains in the members must be calculated accordingly and combined with the dead load strains as found below.

Member of Truss.	PITCH. (Depth to Span.)			
	$\frac{1}{3}$	30°	$\frac{1}{4}$	$\frac{1}{5}$
Fig. 1.				
Aa	.675	.750	.838	1.010
Bb	.537	.625	.726	.917
Ca	.563	.650	.750	.938
Cc	.375	.433	.500	.625
ab	.208	.217	.224	.232
bc	.188	.217	.250	.313
Fig. 2.				
Aa	.750	.833	.930	1.120
Bb	.589	.666	.757	.928
Cc	.568	.666	.783	.995
Da	.625	.721	.833	1.042
Dd	.375	.433	.500	.625
ab	.155	.167	.180	.202
bc	.155	.167	.180	.202
cd	.250	.288	.333	.417
Fig. 3.				
Aa	.788	.874	.978	1.178
Bb	.718	.812	.922	1.131
Cc	.649	.750	.866	1.085
Dd	.580	.687	.810	1.038
Ea	.655	.758	.875	1.094
Ef	.562	.650	.750	.938
Ee	.375	.433	.500	.625
ab	.104	.108	.112	.116
bf	.093	.108	.125	.156
fg	.208	.216	.224	.232
gc	.093	.108	.125	.156
cd	.104	.108	.112	.116
ge	.187	.217	.250	.313
de	.280	.325	.375	.469

NOTE.—Heavy lines denote compression and light lines tension members. Loads are considered as concentrated at the joints.

Fig. 1.

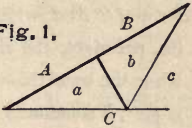


Fig. 2.

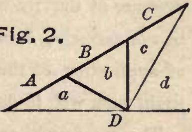
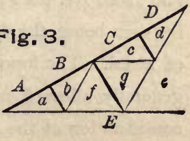


Fig. 3.



EXPLANATION OF TABLES ON RIVETS AND PINS.

PAGES 173 TO 176 INCLUSIVE.

In transmitting strains by means of rivets, it is customary to disregard the friction between the parts joined, as too uncertain an element to be relied upon to any extent. The rivets must then be proportioned for the entire strain which is to be transmitted from one plate, or group of plates, to the other, and they must be of sufficient size and number to present ample resistance to shearing and afford sufficient bearing area so as not to cause a crushing of the metal at the rivet holes. This latter condition, while generally observed for pins, is very often entirely overlooked in riveted work. Its observance, in most cases of riveted girders with single webs, determines the size and number of rivets to be used, and frequently makes it necessary to adopt a greater thickness of web than would otherwise be required. Thus, if the web is $\frac{5}{16}''$ thick, the rivets connecting the same with the flange angles have a bearing value of only 3520 lbs. for a $\frac{3}{4}''$ rivet, while their shearing value is $= 2 \times 3310 = 6620$ lbs. per rivet, the rivets being in double shear. Consequently, while the usual thickness of web of floor beams for railway bridges is $\frac{3}{8}''$, it sometimes becomes necessary, for shallow floor beams, to increase this thickness to $\frac{1}{2}''$ and even $\frac{5}{8}''$, in order that the pressure of the rivets upon the semi-intrados of the rivet holes be not excessive, between the points of support of floor beam and of application of the load, (in which space the transmission of strain from web to flanges takes place).

The most usual pressures allowed upon rivet bearing are 15000 and 12000 lbs. per square inch, as assumed in the tables, the bearing area being the diameter of hole multiplied by the thickness of metal. The former pressure, though somewhat greater than is generally allowed for pins, is frequently used in riveted work in consideration of the neglect of the friction betweer plates.

The heavy zig-zag lines in tables on rivets, indicate the limit at which bearing exceeds single shear. All values above these lines are in excess of single shear, all values below are less than single shear.

Pins must be calculated for shearing, bending and bearing strains, but one of the latter two only, in almost every case, determines the size to be used. The strain allowed upon pin-bearing in bridges proportioned to a factor of safety of five, is usually 12000 lbs., and the maximum fiber strain by bending, 15000 lbs. per square inch. When groups of bars are connected to the same pin, as in the lower chords of truss bridges, the sizes of bars must be so chosen and the bars so placed that at no point on the pin will there be an excessive bending strain, on the presumption that all the bars are strained equally per square inch.

The following examples will illustrate the use of the tables:

I. A pin in the bolster or end shoe of a bridge has to carry a load of 40000 lbs. between two points of support; what size of pin is required, assuming the distance between points (*i. e.*, centers) of support of bolster plates and centers of pressure of end post plates $= 2\frac{1}{2}''$?

Answer:—Bending moment $= 20000$ lbs. $\times 2\frac{1}{2} = 50000$ inch lbs., therefore $3\frac{1}{4}''$ pin required for 15000 lbs. fiber strain, since the allowed moment for $3\frac{1}{4}'' = 50600$, as per table.

II. Required the thickness of metal in the top chord or in a post of a bridge, that will give sufficient bearing area to a $3\frac{3}{8}''$ pin having to transmit a strain of 60700 lbs., the allowed pressure per square inch on bearing being 12000 lbs. maximum.

The bearing value of a $3\frac{3}{8}''$ pin for $1''$ thickness of plate $=$ 40500 lbs. therefore the thickness of metal required $= \dfrac{60700}{40500} =$ $1\frac{1}{2}''$, or each of the two plates in the chord or post will have to be $\frac{3}{4}''$ thick.

MAXIMUM BENDING MOMENTS TO BE ALLOWED ON PINS FOR MAXIMUM FIBER STRAINS OF 15000, 20000 AND 22500 LBS. PER SQUARE INCH.

3/4 830#

Diam. of Pin, Ins.	Moment for S=15000. Lbs. In.	Moment for S=20000. Lbs. In.	Moment for S=22500. Lbs. In.	Diam. of Pin, Ins.	Moment for S=15000 Lbs. In.	Moment for S=20000 Lbs. In.	Moment for S=22500 Lbs. In.
1	1470	1960	2210	4½	134200	178900	201300
1⅛	2100	2800	3140	4⅝	145700	194300	218500
1¼	2880	3830	4310	4¾	157800	210400	236700
1⅜	3830	5100	5740	4⅞	170600	227500	255900
1½	4970	6630	7460	5	184100	245400	276100
1⅝	6320	8430	9480	5⅛	198200	264300	297300
1¾	7890	10500	11800	5¼	213100	284100	319600
1⅞	9710	12900	14600	5⅜	228700	304900	343000
2	11800	15700	17700	5½	245000	326700	367500
2⅛	14100	18800	21200	5⅝	262100	349500	393100
2¼	16800	22400	25200	5¾	280000	373300	419900
2⅜	19700	26300	29600	5⅞	298600	398200	447900
2½	23000	30700	34500	6	318100	424100	477100
2⅝	26600	35500	40000	6⅛	338400	451200	507600
2¾	30600	40800	45900	6¼	359500	479400	539300
2⅞	35000	46700	52500	6⅜	381500	508700	572300
3	39800	53000	59600	6½	404400	539200	606600
3⅛	44900	59900	67400	6⅝	428200	570900	642300
3¼	50600	67400	75800	6¾	452900	603900	679400
3⅜	56600	75500	84900	6⅞	478500	628000	717800
3½	63100	84200	94700	7	505200	673400	757600
3⅝	70100	93500	105200	7½	631200	828400	931900
3¾	77700	103500	116500	8	754000	1005400	1131100
3⅞	85700	114200	128500	8½	904400	1205900	1356700
4	94200	125700	141400	9	1073600	1431400	1609500
4⅛	103400	137800	155000	10	1572600	1888500	2207900
4¼	113000	150700	169600	11	1909900	2613300	2940000
4⅜	123300	164400	185000	12	2150600	3393000	3817100

REMARKS—The following is the formula for the flexure applied to pins:

$$M = \frac{S \pi d^3}{32} \quad \text{or} \quad = \frac{S A d}{8}$$

M=moment of forces for any section through pin.
S=strain per sq. in. in extreme fibers of pin at that section.
A=area of section.
d=diameter.
π=3.14159

The forces are assumed to act in a plane passing through the axis of the pin.

The above table gives the values of M for different diameters of pin, and for three values of S.

If M max. is known, an inspection of the table will therefore show what diameter of pin must be used in order that S may not exceed 15000, 20000 or 22500 lbs., as the requirements of the case may be.

For Railroad Bridges proportioned to a factor of safety of 5, it is customary to make S max. = 15000 lbs. in iron and = 20000 lbs. in steel.

BEARING VALUES OF PINS

FOR ONE INCH THICKNESS OF PLATE.

(=Diameter of Pin × 1″ × Strain per Square Inch.)

Diameter of Pin. inches.	Area of Pin. sq. in.	Bearing Value at 12,000 Lbs. Per Sq. In. lbs.	Bearing Value at 15,000 Lbs. Per Sq. In. lbs.	Diameter of Pin. inches.	Area of Pin. sq. in.	Bearing Value at 12,000 Lbs. Per Sq. In. lbs.	Bearing Value at 15,000 Lbs. Per Sq. In. lbs.
1	.785	12000	15000	4½	15 90	54000	67500
1⅛	.994	13500	16900	4⅝	16.80	55500	69400
1¼	1.227	15000	18800	4¾	17.72	57000	71300
1⅜	1.485	16500	20600	4⅞	18.67	58500	73100
1½	1.767	18000	22500	5	19.64	60000	75000
1⅝	2.074	19500	24400	5⅛	20.63	61500	76900
1¾	2.405	21000	26300	5¼	21.65	63000	78800
1⅞	2.761	22500	28100	5⅜	22.69	64500	80600
2	3.142	24000	30000	5½	23.76	66000	82500
2⅛	3.547	25500	31900	5⅝	24.85	67500	84400
2¼	3.976	27000	33800	5¾	25.97	69000	86300
2⅜	4.430	28500	35600	5⅞	27.11	70500	88100
2½	4.909	30000	37500	6	28.27	72000	90000
2⅝	5.412	31500	39400	6⅛	29.46	73500	91900
2¾	5.940	33000	41300	6¼	30.68	75000	93800
2⅞	6.492	34500	43100	6⅜	31.92	76500	95600
3	7.069	36000	45000	6½	33.18	78000	97500
3⅛	7.670	37500	46900	6⅝	34 47	79500	99400
3¼	8.296	39000	48800	6¾	35.79	81000	101300
3⅜	8.946	40500	50600	6⅞	37.12	82500	103100
3½	9.621	42000	52500	7	38.48	84000	105000
3⅝	10.32	43500	54400	7½	44.18	90000	112500
3¾	11.05	45000	56300	8	50.27	96000	120000
3⅞	11.79	46500	58100	8½	56.75	102000	127500
4	12.57	48000	60000	9	63.62	108000	135000
4⅛	13.36	49500	61900	10	78.54	120000	150000
4¼	14 19	51000	63800	11	95.03	132000	165000
4⅜	15.03	52500	65600	12	113.10	144000	180000

SHEARING AND BEARING VALUE OF RIVETS.

Diam. of Rivet in inches.		Area of Rivet.	Single Shear at 7500 lbs. per sq. inch.	Bearing Value for different Thicknesses of Plate at 15000 lbs. per square inch. (=Diameter of Rivet × Thickness of Plate × 15000 lbs.)										
Fraction.	Decimal.			1/4″	5/16″	3/8″	7/16″	1/2″	9/16″	5/8″	11/16″	3/4″	13/16″	7/8″
3/8	.375	.1104	828	1410										
7/16	.4375	.1503	1130	1640	2050									
1/2	.5	.1963	1470	1880	2340	2810								
9/16	.5625	.2485	1860	2110	2640	3160	3690							
5/8	.625	.3068	2300	2340	2930	3520	4100							
11/16	.6875	.3712	2780	2580	3220	3870	4510	5160						
3/4	.75	.4418	3310	2810	3520	4220	4920	5630	6330					
13/16	.8125	.5185	3890	3050	3810	4570	5330	6090	6860	7620				
7/8	.875	.6013	4510	3280	4100	4920	5740	6560	7380	8200				
15/16	.9375	.6903	5180	3520	4390	5270	6150	7030	7910	8790	9670			
1	1.0	.7854	5890	3750	4690	5620	6560	7500	8440	9380	10310	11250		
1 1/16	1.0625	.8866	6650	3980	4980	5980	6970	7970	8960	9960	10960	11950	12950	
1 1/8	1.125	.9940	7460	4220	5270	6330	7380	8440	9490	10550	11600	12660	13710	14770
1 3/16	1.1875	1.1075	8310	4450	5570	6680	7790	8910	10020	11130	12250	13360	14470	15590

SHEARING AND BEARING VALUE OF RIVETS.

Diam. of Rivet in inches.		Area of Rivet.	Single Shear at 6000lbs. per sq. inch.	Bearing Value for different Thicknesses of Plate at 12000 lbs. per square inch. (=Diameter of Rivet × Thickness of Plate × 12000 lbs.)										
Fraction.	Decimal.			1/4″	5/16″	3/8″	7/16″	1/2″	9/16″	5/8″	11/16″	3/4″	13/16″	7/8″
3/8	.375	.1104	660	1130										
7/16	.4375	.1503	900	1310	1640									
1/2	.5	.1963	1180	1500	1880	2250								
9/16	.5625	.2485	1490	1690	2110	2530	2950							
5/8	.625	.3068	1840	1880	2340	2810	3280							
11/16	.6875	.3712	2230	2060	2580	3090	3610	4130						
3/4	.75	.4418	2650	2250	2810	3380	3940	4500	5060					
13/16	.8125	.5185	3110	2440	3050	3660	4260	4880	5480	6090				
7/8	.875	.6013	3610	2630	3280	3940	4590	5250	5910	6560				
15/16	.9375	.6903	4140	2810	3520	4220	4920	5630	6330	7030	7730			
1	1.0	.7854	4710	3000	3750	4500	5250	6000	6750	7500	8250	9000		
1 1/16	1.0625	.8866	5320	3190	3980	4780	5580	6380	7190	7970	8770	9560	10360	
1 1/8	1.125	.9940	5960	3380	4220	5060	5910	6750	7590	8440	9280	10130	10970	11810
1 3/16	1.1875	1.1075	6650	3560	4450	5340	6230	7130	8020	8910	9800	10690	11580	12470

SPECIFICATIONS FOR CONSTRUCTIONAL IRON.

Character and Finish. 1. All wrought iron must be tough, ductile, fibrous and of uniform quality. Finished bars must be thoroughly welded during the rolling, and be straight, smooth and free from injurious seams, blisters, buckles, cracks or imperfect edges.

Manufacture. 2. No specific process or provision of manufacture will be demanded, provided the material fulfills the requirements of these specifications.

Standard Test Piece. 3. The tensile strength, limit of elasticity and ductility, shall be determined from a standard test piece of as near ½ square inch sectional area as possible. The elongation shall be measured on an original length of 8 inches.

Elastic Limit. 4. Iron of all grades shall have an elastic limit of not less than 26,000 pounds per square inch.

High Test or Tension Iron. 5. When tested in specimens of uniform sectional area of at least ½ square inch, taken from members which have been rolled to a section of not more than 4½ square inches, the iron shall show a minimum ultimate strength of 50,000 pounds per square inch, and a minimum elongation of 18 per cent. in 8 inches.

6. Specimens taken from bars of a larger cross section than 4½ square inches, will be allowed a reduction of 500 pounds for each additional square inch of section, down to a minimum of 48,000 pounds, and have an elongation of 15 per cent. in 8 inches.

Bending Test. 7. All iron for tension members must bend cold through 90 degrees to a curve whose diameter is not over twice the thickness of the piece, without cracking. At least one sample in three must bend through 180 degrees to this curve, without cracking. When nicked on one side and bent by a blow from a sledge, the fracture must be mostly fibrous.

Angle and Other Shaped Iron. 8. The same sized specimens taken from angle and other shaped iron shall have a minimum ultimate strength of 48,000 pounds per square inch, and a minimum elongation of 15 per cent. in 8 inches.

9. Specimens from angle and other shaped iron must bend cold through 90 degrees to a curve whose diameter is not over twice the thickness of the piece, without cracking.

PLATES.

10. The same sized specimens, taken from plates 8 inches to 24 inches in width, shall show a minimum ultimate strength of 48,000 pounds per square inch, and a minimum elongation of 15 per cent. in 8 inches; plates from 24 inches to 36 inches wide shall show a minimum ultimate strength of 46,000 pounds per square inch, and elongate 10 per cent. in 8 inches; plates over 36 inches wide shall have a minimum elongation of 8 per cent. in 8 inches.

11. Samples of plate iron shall stand bending cold through 90 degrees to a curve whose diameter is not over three times its thickness, without cracking. When nicked and bent cold, the fracture must be mostly fibrous.

RIVET IRON.

12. Rivet iron shall have the same physical requirements as high test iron, and, in addition, shall bend cold 180 degrees to a curve whose diameter is equal to the thickness of the rod tested, without sign of fracture on the convex side.

PIN IRON.

13. Specimens taken from pin iron under 4 inches diameter shall have a minimum ultimate strength of 50,000 pounds per square inch, and elongate 15 per cent. in 8 inches. Rounds over 4 inches diameter, having a minimum elongation of 10 per cent. in 8 inches will be satisfactory.

FULL SIZE TEST.

14. Full size pieces of flat, round or square iron not over 4½ inches in sectional area, shall have an ultimate strength of 50,000 pounds per square inch, and stretch 12½ per cent. in the body of the bar. Bars of a larger sectional area than 4½ square inches, will be allowed a reduction of 1,000 pounds per square inch, down to a minimum of 46,000 pounds per square inch, and stretch 10 per cent. in the body of the bar.

VARIATION IN WEIGHT.

15. The variation in cross section or weight of rolled material of more than 2½ per cent. from that specified, may be cause for rejection.

SPECIFICATIONS FOR CONSTRUCTIONAL STEEL.

PROCESS OF MANUFACTURE. 1. Steel may be made by either the Open Hearth or Bessemer process.

TEST PIECES. 2. The tensile strength, limit of elasticity and ductility shall be determined from a standard test piece cut from the finished material and planed or turned parallel; the piece to have as near ½ square inch sectional area as possible, and elongation to be measured on an original length of 8 inches; two test pieces to be taken from each heat or blow of finished material, one for tension and one for bending.

3. Every finished piece of steel shall be stamped on one side near the middle with the blow number identifying the melt; and steel for pins shall have the melt number stamped on the ends. Rivet and lacing steel, and small pieces for pin plates and stiffeners, may be shipped in bundles securely wired together, with the melt number on a metal tag attached.

FINISH. 4. Finished bars must be free from injurious seams, flaws or cracks and have a workmanlike finish.

GRADE OF STEEL. 5. Steel shall be of three grades: SOFT, MEDIUM, HIGH.

SOFT STEEL. 6. Specimens from finished material for test, cut to size specified above, shall have an ultimate strength of from 54,000 to 62,000 pounds per square inch; elastic limit one-half the ultimate strength; minimum elongation of 26 per cent. in 8 inches; minimum reduction of area at fracture 50 per cent. This grade of steel to bend cold 180 degrees flat on itself, without sign of fracture on the outside of the bent portion.

MEDIUM STEEL. 7. Specimens from finished material for test, cut to size specified above, shall have an ultimate strength of 60,000 to 68,000 pounds per square inch; elastic limit one-half the ultimate strength; minimum elongation 20 per cent. in 8 inches; minimum reduction of area at fracture, 40 per cent. This grade of steel to bend cold 180 degrees to a diameter equal to the thickness of the piece tested, without crack or flaw on the outside of the bent portion.

HIGH STEEL. 8. Specimens from finished material for test, cut to size specified above, shall have an ultimate strength of 66,000 pounds to 74,000 pounds per square inch; elastic limit one-half the ultimate strength; minimum elongation 18 per cent. in 8 inches; minimum reduction of area at fracture, 35 per cent. This grade of steel to bend cold 180 degrees, to a diameter equal to three times the thickness of the test piece, without crack or flaw on the outside of the bent portion.

PIN STEEL. 9. Pins made of either of the above mentioned grades of steel, shall, on specimen test pieces cut from finished material, fill the physical requirements of the grade of steel from which it is rolled, for ultimate strength, elastic limit and bending, but the elongation shall be decreased 5 per cent., and reduction of area at fracture 10 per cent. from that specified.

VARIATION IN WEIGHT. 10. The variation in cross-section or weight of more than 2½ per cent. from that specified, will be sufficient cause for rejection.

FULL SIZE TESTS OF STEEL BARS. 11. Full size tests of steel used for eye-bars shall not be required to show more than 10 per cent. elongation in the body of the bar, and tensile strength not more than 4,000 pounds below the minimum tensile strength required in specimen tests, of the grade of steel from which it is rolled.

SPECIFICATIONS FOR CONSTRUCTIONAL CAST IRON.

1. Except where chilled iron is specified, all castings shall be tough gray iron, free from injurious cold shuts or blow holes, true to pattern and of a workmanlike finish. Sample pieces 1 inch square cast from the same heat of metal in sand molds shall be capable of sustaining on a clear span of 4 feet 6 inches a central load of 500 pounds when tested in the rough bar.

SPECIFICATIONS FOR WORKMANSHIP.

INSPECTION. 1. Inspection of work shall be made as it progresses, and at as early a period as the nature of the work permits.

2. All workmanship must be first class. All abutting surfaces of compression members, except flanges of plate girders where the joints are fully spliced, must be planed or turned to even bearings so that they shall be in such contact throughout as may be obtained by such means. All finished surfaces must be protected by white lead and tallow.

3. The rivet holes for splice plates of abutting members shall be so accurately spaced that when the members are brought into position the holes shall be truly opposite before the rivets are driven.

4. Rollers must be finished perfectly round and roller-beds planed.

RIVETS. 5. The pitch of rivets in all classes of work shall never exceed 6 inches, nor 16 times the thinnest outside plate, nor be less than 3 diameters of the rivet. The rivets used shall generally be ⅝, ¾ and ⅞ inch diameter. The distance between the edge of any piece and the center of a rivet hole must never be less than 1¼ inches, except for bars less than 2½ inches wide. When practicable it shall be at least two diameters of the rivet. Rivets must completely fill the holes, have full heads concentric with the rivet, of a height not less than .6 the diameter of the rivet, and in full contact with the surface, or be countersunk when so required, and machine-driven wherever practicable.

PUNCHING. 6. The diameter of the punch shall not exceed by more than 1-16 inch the diameter of the rivets to be used, and all holes must be clean cuts without torn or ragged edges. Rivet holes must be accurately spaced; the use of drift pins will be allowed only for bringing together the several parts forming a member, and they must not be driven with such force as to disturb the metal about the holes.

7. Built members must, when finished, be true and free from twists, kinks, buckles, or open joints between the component pieces.

EYE BARS AND PIN-HOLES. 8. All pin-holes must be accurately bored at right angles to the axis of the members, unless otherwise shown in the draw-

ings, and in pieces not adjustable for length no variation of more than 1-32 of an inch will be allowed in the length between centers of pin-holes; the diameter of the pin-holes shall not exceed that of the pins by more than 1-32 inch, nor by more than 1-50 inch for pins under 3½ inches diameter. Eye-bars must be straight before boring; the holes must be in the center of the heads, and on the center line of the bars. Whenever eye-bars are to be packed more than ⅛ of an inch to the foot of their length out of parallel with the axis of the structure, they must be bent with a gentle curve until the head stands at right angles to the pin in their intended position before being bored. All eye-bars belonging to the same panel, when placed in a pile, must allow the pin at each end to pass through at the same time without forcing. No welds will be allowed in the body of the bar of eye-bars, laterals or counters, except to form the loops of laterals, counters and sway rods; eyes of laterals, stirrups, sway rods and counters must be bored; pins and lateral bolts must be finished perfectly round and straight, and the party contracting to erect the work must provide pilot nuts where necessary to preserve the threads while the pins are being driven. Thimbles or washers must be used whenever required to fill the vacant spaces on pins or bolts.

PILOT NUTS.

ANNEALING.

9. In all cases where a steel piece in which the full strength is required has been partially heated the whole piece must be subsequently annealed. All bends in steel must be made cold, or if the degree of curvature is so great as to require heating, the whole piece must be subsequently annealed.

PAINTING.

10. All surfaces inaccessible after assembling must be well painted or oiled before the parts are assembled.

11. The decision of the engineer shall control as to the interpretation of drawings and specifications during the execution of work thereunder, but this shall not deprive the contractor of his right to redress, after the completion of the work, for an improper decision

NOTES ON STEEL AND IRON.

1. The average weight of wrought iron is 480 lbs. per cubic foot. A bar 1 inch square and 3 feet long weighs, therefore, exactly 10 lbs. Hence:

To find the sectional area, given the weight per foot:
Multiply by $\frac{3}{10}$.

To find the weight per foot, given the sectional area:
Multiply by $\frac{10}{3}$.

2. The weight of steel is 2 per cent. greater than that of wrought iron.

3. The center load, at which a bar of wrought iron 1 inch square and 12 inches center to center of points of support will give way, is very nearly *one ton* (of 2,240 lbs.)

4. Within the elastic limit, the extension and compression of wrought iron is very nearly $\frac{1}{10000}$ of its length for a strain of *one ton* (of 2,240 lbs.) per square inch.

For cast iron this ratio is $\frac{1}{5000}$ for tension, but becomes variable for compression.

5. The contraction or expansion of wrought iron under changes of temperature is about $\frac{1}{10000}$ of its length, for a variation of 15° Fahrenheit.

The strain thus induced, if the ends are held rigidly fixed, will be about *one ton* (of 2,240 lbs.) per square inch of cross-section.

6. The coefficient of expansion of wrought iron, for 100° Fahrenheit, is 0.000686. Therefore, for a variation in temperature of 125°, a bar of wrought iron 100 feet long will expand or contract 1.029 inches.

Conversely: A change in length of 1 inch per hundred feet would be produced by a variation in temperature of 121 5° Fahrenheit.

7. The melting point of iron and steel is about as follows:

Wrought iron, . .	3,000° Fahrenheit.
Cast iron, ...	2,000° "
Steel, ...	2,400° "

8. The welding heat of wrought iron is 2,733° Fahrenheit.

MISCELLANEOUS NOTES.

1. Thrust of arch per lineal foot:

$$T = \frac{1.5\ wl^2}{r},$$ in which w = load per square foot, r = rise in arch in inches, and l = span in feet.

2. Approximately the radius of gyration for a box section is $\frac{4}{10}$ the least side.

WOODEN PILLARS.

Extensive tests have been made at the Watertown Arsenal, Mass., to determine the resistance of wooden posts to crushing. These tests, conducted partly by the U. S. Government and partly by Prof. Lanza, furnish the most reliable data existing at present on this subject.

Prof. Lanza's experiments were made upon short rectangular blocks and upon circular posts such as are commonly used in mills. In diameter the latter ranged from 6½ to 10½ inches, in some cases tapering slightly towards the top. They were from 2 to 14 feet in length and were tested with flat ends.

The following are the results thus obtained:

ULTIMATE RESISTANCE TO COMPRESSION.

POUNDS PER SQUARE INCH.

KIND OF TIMBER.	MAXIMUM.	MINIMUM.	MEAN.
White Oak, . . .	4450	3006	3470
Yellow Pine, . . .	5452	3604	4544

The timber employed in these tests was neither green nor thoroughly seasoned. It was selected so as to fairly represent its condition as ordinarily used for constructional purposes.

Prof. Lanza made further a series of tests upon old and thoroughly seasoned mill posts of white oak, some varying from 6¾ inches diameter at the base to 5¾ inches at the top, and others having a uniform diameter of about 10 inches. They were approximately from 12 to 14 feet in length. For the ultimate resistance to compression in this case he obtained an average value of 3,957 pounds per square inch. It is to be noted that this result is only about 14 per cent. in excess of the mean value given above for similar posts of white oak of the character there described.

In all the foregoing tests, failure took place by direct crushing, the bending of the post being too inconsiderable to materially affect the result.

The other series of tests conducted at the Watertown Arsenal, was made upon rectangular posts with flat ends having a length of from 5 to 28 feet, and ranging in sectional area from 27 to 140 square inches.

The results may be generalized as follows, calling $\frac{1}{s}$ the ratio of length of post to least side of cross-section, and f the ultimate resistance to compression, in pounds per square inch:

WHITE PINE.			YELLOW PINE.		
$\frac{l}{s}$	f	Ratio of Decrease.	$\frac{l}{s}$	f	Ratio of Decrease.
0 to 10	2500	1.00	0 to 15	4000	1.00
10 " 35	2000	0.80	15 " 30	3500	0.88
35 " 45	1500	0.60	30 " 40	3000	0.75
45 " 60	1000	0.40	40 " 45	2500	0.63
			45 " 50	2000	0.50
			50 " 60	1500	0.38

Experiments upon white oak posts of such lengths have up to the present time not been made. Probably values from 75 per cent. to 80 per cent. of those given for yellow pine may be safely assumed.

WOODEN BEAMS.

The following is a general summary of the results obtained by Prof. Lanza from numerous experiments upon wooden beams.

They were of an average section of about 12x4 inches and were tested for mean span lengths of about 18 feet:

KIND OF TIMBER.	Modulus of Rupture $=\frac{M}{R}=\frac{\text{(Moment of forces causing rupture.)}}{\text{(Moment of resistance of cross section.)}}$		
	Maximum.	Minimum.	Mean.
Spruce, . . .	5878	2995	4884
White Pine, . .	6415	3438	4808
Oak, ...	7659	4984	6075
Yellow Pine, . .	11360	5092	7292

The above statement of the maximum and minimum values does not consider the results obtained in a few isolated cases for which the conditions were radically different than for the others. It was found that the beams frequently gave way through longitudinal shearing near the neutral axis, though this was not as common a source of failure as breaking across the grain.

For spruce, the mean intensity of the shearing strains, for beams that failed in this manner, was 191 lbs., and for yellow pine 248 lbs. For beams that failed otherwise, the mean intensity of shearing strains at the moment of rupture was very nearly the same.

The conclusion appears, therefore, to be warranted that for soft timber there is an almost equal tendency for beams to fail by shearing longitudinally at the neutral axis, as by the tearing of the outside fibers.

Owing to the wide range of the results obtained and the generally erratic behavior of timber subjected to strains, Prof. Lanza recommends the following values for Moduli of Rupture to be adopted in practice:

Spruce and White pine, ...	3,000 lbs.
Oak, ...	4,000 "
Yellow pine, . . . , . .	5,000 "

These values are lower than heretofore in use and a safety factor of 4, on the basis of these values, may be assumed as ample for all cases.

The following table has been calculated for extreme fibre strains of 750 lbs. per square inch:

SAFE LOADS, UNIFORMLY DISTRIBUTED, FOR RECTANGULAR SPRUCE OR WHITE PINE BEAMS.

ONE INCH THICK.

(For oak, increase values in table by ⅓.)
(For yellow pine, increase values in table by ⅔.)

Span in feet.	DEPTH OF BEAM.										
	6″	7″	8″	9″	10″	11″	12″	13″	14″	15″	16″
5	600	820	1070	1350	1670	2020	2400	2820	3270	3750	4270
6	500	680	890	1120	1390	1680	2000	2350	2730	3120	3560
7	430	580	760	960	1190	1440	1710	2010	2330	2680	3050
8	380	510	670	840	1040	1260	1500	1760	2040	2340	2670
9	330	460	590	750	930	1120	1330	1560	1810	2080	2370
10	300	410	530	670	830	1010	1200	1410	1630	1880	2130
11	270	370	490	610	760	920	1090	1280	1490	1710	1940
12	250	340	440	560	690	840	1000	1180	1360	1560	1780
13	230	310	410	520	640	780	930	1080	1260	1440	1640
14	210	290	380	480	590	720	860	1010	1170	1340	1530
15	200	270	360	450	560	670	800	940	1090	1250	1420
16	190	260	330	420	520	630	750	880	1020	1180	1330
17	180	240	310	400	490	590	710	830	960	1100	1260
18	170	230	290	370	460	560	670	780	910	1040	1190
19	160	210	280	360	440	530	630	740	860	990	1130
20	150	200	270	340	420	510	600	710	820	940	1070
21	140	190	260	320	390	480	570	670	780	890	1020
22	140	190	240	310	380	460	540	640	740	850	970
23	130	180	230	290	360	440	520	610	710	810	920
24	130	170	220	280	350	420	500	590	680	780	890
25	120	160	210	270	330	410	480	560	660	750	860
26	110	160	210	260	320	390	460	540	630	720	820
27	110	150	200	250	310	370	440	520	610	690	790
28	110	140	190	240	300	360	430	500	580	670	760
29	110	140	180	230	290	350	410	490	560	640	740

To obtain the safe load for any thickness: Multiply values for 1 inch by thickness of beam.

To obtain the required thickness for any load: Divide by safe load for 1 inch.

STRENGTH OF MATERIALS.

ULTIMATE RESISTANCE TO TENSION

IN LBS. PER SQUARE INCH.

METALS AND ALLOYS.

	AVERAGE.
Aluminum Bronze,	
10 per cent Al. and 90 per cent. Copper,	85000
1¼ " " 98¾ " "	28000
Brass, cast,	18000
" wire,	49000
Bronze or gun metal,	36000
Copper, cast,	19000
" sheet,	30000
" bolts,	36000
" wire, (unannealed,)	60000
Iron, cast, 13,400 to 29,000,	16500
" wrought, round or square bars of 1 to 2 inch diameter, double refined,	50000 to 54000
" wrought, specimens ½ inch square, cut from large bars of double refined iron,	50000 to 53000
" wrought, double refined, in large bars of about 7 square inches section,	46000 to 47000
" wrought, universal mill plates, angles and other shapes,	48000 to 51000
" wrought plates over 36″ wide,	46000 to 50000

The modulus of elasticity of Union Iron Mills' double refined bar iron is 25000000 to 27000000 from tests made on finished eye bars.

Iron, wire,	70000 to 100000
" wire ropes,	90000
Lead, sheet,	3300
Steel,	65000 to 120000
Tin, cast,	4600
Zinc,	7000 to 8000

STRENGTH OF MATERIALS.—Continued.

TIMBER, SEASONED, AND OTHER ORGANIC FIBER.

Taken largely from Trautwine's pocket book, (edition of 1888.)

	AVERAGE.
Ash, English,	17000
" American,	16000
Beech, "	15000 to 18000
Birch,	15000
Cedar of Lebanon,	11400
" American, red,	10300
Fir or Spruce,	10000
Hempen Ropes,	12000 to 16000
Hickory, American,	11000
Mahogany,	8000 to 21800
Oak, American, white,	10000 to 18000
" European,	10000 to 19800
Pine, American, white, red and pitch, Memel, Riga,	10000
" " long leaf yellow,	12600 to 19200
Poplar,	7000
Silk fiber,	52000
Walnut, black,	16000

STONE, NATURAL AND ARTIFICIAL.

Brick and Cement,	280 to 300
Glass,	9400
Slate,	9600 to 12800
Mortar, ordinary,	50

ULTIMATE RESISTANCE TO COMPRESSION.

METALS.

Brass, cast,	10300
Iron, "	82000 to 145000
" wrought,	36000 to 40000

STRENGTH OF MATERIALS.—Continued.

TIMBER, SEASONED, COMPRESSED IN THE DIRECTION OF THE GRAIN.

Taken largely from Trautwine's pocket book, (edition of 1888.)

	AVERAGE.
Ash, American,	6800
Beech, "	7000
Birch,	8000
Cedar of Lebanon,	5900
" American, red,	6000
Chestnut,	5300
Deal, red,	6500
Fir or Spruce,	5000
Hickory,	8000
Oak, American, white,	7000
" British,	10000
" Dantzig,	7700
Pine, American, white,	5400
" " long leaf yellow,	8500
Walnut, black,	8000

STONE, NATURAL AND ARTIFICIAL.

Brick, weak,	550 to 800
" strong,	1100
" fire,	1700
Brickwork, ordinary, in cement,	300 to 600
" best,	1000
Granite,	5000 to 18000
Limestone,	4000 to 16000
Sandstone, ordinary,	2500 to 10000

ULTIMATE RESISTANCE TO SHEARING.

METALS.

Iron, cast,	25000
" wrought, along the fiber,	45000

TIMBER, SEASONED, ALONG THE GRAIN.

White Pine, Spruce, Hemlock,	250 to 500
Yellow Pine, long leaf,	300 to 600
Oak,	400 to 700

LINEAR EXPANSION OF SUBSTANCES BY HEAT.

To find the increase in the length of a bar of any material due to an increase of temperature, multiply the number of degrees of increase of temperature by the coefficient for 100 degrees and by the length of the bar, and divide by 100.

Name of Substance.	Coefficient for 100° Fahrenheit.	Coefficient for 180° Fahrenheit, or 100 Centigrade.
Baywood, (in the direction of the grain, dry,)	.00026 to .00031	.00046 to .00057
Brass, (cast,)	.00104	.00188
" (wire,)	.00107	.00193
Brick, (fire,)	.0003	.0005
Cement, (Roman,)	.0008	.0014
Copper,	.0009	.0017
Deal, (in the direction of the grain, dry,)	.00024	.00044
Glass, (English flint,)	.00045	.00081
" (French white lead,)	.00048	.00087
Gold,	.0008	.0015
Granite, (average,)	.00047	.00085
Iron, (cast,)	.0006	.0011
" (soft forged,)	.0007	.0012
" (wire,)	.0008	.0014
Lead,	.0016	.0029
Marble, (Carrara,)	.00036 to .0006	.00065 to .0011
Mercury,	.0033	.0060
Platinum,	.0005	.0009
Sandstone,	.0005 to .0007	.0009 to .0012
Silver,	.0011	.002
Slate, (Wales,)	.0006	.001
Water, (varies considerably with the temperature,)	.0086	.0155

AREAS OF FLAT ROLLED BARS,

For Thicknesses from 1/16 in. to 2 in. and Widths from 1 in. to 12¾ in.

Thickness in Inches.	1″	1¼″	1½″	1¾″	2″	2¼″	2½″	2¾″	12″
1/16	.063	.078	.094	.109	.125	.141	.156	.172	.750
1/8	.125	.156	.188	.219	.250	.281	.313	.344	1.50
3/16	.188	.234	.281	.328	.375	.422	.469	.516	2.25
1/4	.250	.313	.375	.438	.500	.563	.625	.688	3.00
5/16	.313	.391	.469	.547	.625	.703	.781	.859	3.75
3/8	.375	.469	.563	.656	.750	.844	.938	1.03	4.50
7/16	.438	.547	.656	.766	.875	.984	1.09	1.20	5.25
1/2	.500	.625	.750	.875	1.00	1.13	1.25	1.38	6.00
9/16	.563	.703	.844	.984	1.13	1.27	1.41	1.55	6.75
5/8	.625	.781	.938	1.09	1.25	1.41	1.56	1.72	7.50
11/16	.688	.859	1.03	1.20	1.38	1.55	1.72	1.89	8.25
3/4	.750	.938	1.13	1.31	1.50	1.69	1.88	2.06	9.00
13/16	.813	1.02	1.22	1.42	1.63	1.83	2.03	2.23	9.75
7/8	.875	1.09	1.31	1.53	1.75	1.97	2.19	2.41	10.50
15/16	.938	1.17	1.41	1.64	1.88	2.11	2.34	2.58	11.25
1	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	12.00
1 1/16	1.06	1.33	1.59	1.86	2.13	2.39	2.66	2.92	12.75
1 1/8	1.13	1.41	1.69	1.97	2.25	2.53	2.81	3.09	13.50
1 3/16	1.19	1.48	1.78	2.08	2.38	2.67	2.97	3.27	14.25
1 1/4	1.25	1.56	1.88	2.19	2.50	2.81	3.13	3.44	15.00
1 5/16	1.31	1.64	1.97	2.30	2.63	2.95	3.28	3.61	15.75
1 3/8	1.38	1.72	2.06	2.41	2.75	3.09	3.44	3.78	16.50
1 7/16	1.44	1.80	2.16	2.52	2.88	3.23	3.59	3.95	17.25
1 1/2	1.50	1.88	2.25	2.63	3.00	3.38	3.75	4.13	18.00
1 9/16	1.56	1.95	2.34	2.73	3.13	3.52	3.91	4.30	18.75
1 5/8	1.63	2.03	2.44	2.84	3.25	3.66	4.06	4.47	19.50
1 11/16	1.69	2.11	2.53	2.95	3.38	3.80	4.22	4.64	20.25
1 3/4	1.75	2.19	2.63	3.06	3.50	3.94	4.38	4.81	21.00
1 13/16	1.81	2.27	2.72	3.17	3.63	4.08	4.53	4.98	21.75
1 7/8	1.88	2.34	2.81	3.28	3.75	4.22	4.69	5.16	22.50
1 15/16	1.94	2.42	2.91	3.39	3.88	4.36	4.84	5.33	23.25
2	2.00	2.50	3.00	3.50	4.00	4.50	5.00	5.50	24.00

AREAS OF FLAT ROLLED BARS.

(CONTINUED.)

Thickness in Inches.	3″	3¼″	3½″	3¾″	4″	4¼″	4½″	4¾″	12″
1/16	.188	.203	.219	.234	.250	.266	.281	.297	.750
1/8	.375	.406	.438	.469	.500	.531	.563	.594	1.50
3/16	.563	.609	.656	.703	.750	.797	.844	.891	2.25
1/4	.750	.813	.875	.938	1.00	1.06	1.13	1.19	3.00
5/16	.938	1.02	1.09	1.17	1.25	1.33	1.41	1.48	3.75
3/8	1.13	1.22	1.31	1.41	1.50	1.59	1.69	1.78	4.50
7/16	1.31	1.42	1.53	1.64	1.75	1.86	1.97	2.08	5.25
1/2	1.50	1.63	1.75	1.88	2.00	2.13	2.25	2.38	6.00
9/16	1.69	1.83	1.97	2.11	2.25	2.39	2.53	2.67	6.75
5/8	1.88	2.03	2.19	2.34	2.50	2.66	2.81	2.97	7.50
11/16	2.06	2.23	2.41	2.58	2.75	2.92	3.09	3.27	8.25
3/4	2.25	2.44	2.63	2.81	3.00	3.19	3.38	3.56	9.00
13/16	2.44	2.64	2.84	3.05	3.25	3.45	3.66	3.86	9.75
7/8	2.63	2.84	3.06	3.28	3.50	3.72	3.94	4.16	10.50
15/16	2.81	3.05	3.28	3.52	3.75	3.98	4.22	4.45	11.25
1	3.00	3.25	3.50	3.75	4.00	4.25	4.50	4.75	12.00
1 1/16	3.19	3.45	3.72	3.98	4.25	4.52	4.78	5.05	12.75
1 1/8	3.38	3.66	3.94	4.22	4.50	4.78	5.06	5.34	13.50
1 3/16	3.56	3.86	4.16	4.45	4.75	5.05	5.34	5.64	14.25
1 1/4	3.75	4.06	4.38	4.69	5.00	5.31	5.63	5.94	15.00
1 5/16	3.94	4.27	4.59	4.92	5.25	5.58	5.91	6.23	15.75
1 3/8	4.13	4.47	4.81	5.16	5.50	5.84	6.19	6.53	16.50
1 7/16	4.31	4.67	5.03	5.39	5.75	6.11	6.47	6.83	17.25
1 1/2	4.50	4.88	5.25	5.63	6.00	6.38	6.75	7.13	18.00
1 9/16	4.69	5.08	5.47	5.86	6.25	6.64	7.03	7.42	18.75
1 5/8	4.88	5.28	5.69	6.09	6.50	6.91	7.31	7.72	19.50
1 11/16	5.06	5.48	5.91	6.33	6.75	7.17	7.59	8.02	20.25
1 3/4	5.25	5.69	6.13	6.56	7.00	7.44	7.88	8.31	21.00
1 13/16	5.44	5.89	6.34	6.80	7.25	7.70	8.16	8.61	21.75
1 7/8	5.63	6.09	6.56	7.03	7.50	7.97	8.44	8.91	22.50
1 15/16	5.81	6.30	6.78	7.27	7.75	8.23	8.72	9.20	23.25
2	6.00	6.50	7.00	7.50	8.00	8.50	9.00	9.50	24.00

AREAS OF FLAT ROLLED BARS.

(CONTINUED.)

Thickness in Inches.	5″	5¼″	5½″	5¾″	6″	6¼″	6½″	6¾″	12″
1/16	.313	.328	.344	.359	.375	.391	.406	.422	.750
1/8	.625	.656	.688	.719	.750	.781	.813	.844	1.50
3/16	.938	.984	1.03	1.08	1.13	1.17	1.22	1.27	2.25
1/4	1.25	1.31	1.38	1.44	1.50	1.56	1.63	1.69	3.00
5/16	1.56	1.64	1.72	1.80	1.88	1.95	2.03	2.11	3.75
3/8	1.88	1.97	2.06	2.16	2.25	2.34	2.44	2.53	4.50
7/16	2.19	2.30	2.41	2.52	2.63	2.73	2.84	2.95	5.25
1/2	2.50	2.63	2.75	2.88	3.00	3.13	3.25	3.38	6.00
9/16	2.81	2.95	3.09	3.23	3.38	3.52	3.66	3.80	6.75
5/8	3.13	3.28	3.44	3.59	3.75	3.91	4.06	4.22	7.50
11/16	3.44	3.61	3.78	3.95	4.13	4.30	4.47	4.64	8.25
3/4	3.75	3.94	4.13	4.31	4.50	4.69	4.88	5.06	9.00
13/16	4.06	4.27	4.47	4.67	4.88	5.08	5.28	5.48	9.75
7/8	4.38	4.59	4.81	5.03	5.25	5.47	5.69	5.91	10.50
15/16	4.69	4.92	5.16	5.39	5.63	5.86	6.09	6.33	11.25
1	5.00	5.25	5.50	5.75	6.00	6.25	6.50	6.75	12.00
1 1/16	5.31	5.58	5.84	6.11	6.38	6.64	6.91	7.17	12.75
1 1/8	5.63	5.91	6.19	6.47	6.75	7.03	7.31	7.59	13.50
1 3/16	5.94	6.23	6.53	6.83	7.13	7.42	7.72	8.02	14.25
1 1/4	6.25	6.56	6.88	7.19	7.50	7.81	8.13	8.44	15.00
1 5/16	6.56	6.89	7.22	7.55	7.88	8.20	8.53	8.86	15.75
1 3/8	6.88	7.22	7.56	7.91	8.25	8.59	8.94	9.28	16.50
1 7/16	7.19	7.55	7.91	8.27	8.63	8.98	9.34	9.70	17.25
1 1/2	7.50	7.88	8.25	8.63	9.00	9.38	9.75	10.13	18.00
1 9/16	7.81	8.20	8.59	8.98	9.38	9.77	10.16	10.55	18.75
1 5/8	8.13	8.53	8.94	9.34	9.75	10.16	10.56	10.97	19.50
1 11/16	8.44	8.86	9.28	9.70	10.13	10.55	10.97	11.39	20.25
1 3/4	8.75	9.19	9.63	10.06	10.50	10.94	11.38	11.81	21.00
1 13/16	9.06	9.52	9.97	10.42	10.88	11.33	11.78	12.23	21.75
1 7/8	9.38	9.84	10.31	10.78	11.25	11.72	12.19	12.66	22.50
1 15/16	9.69	10.17	10.66	11.14	11.63	12.11	12.59	13.08	23.25
2	10.00	10.50	11.00	11.50	12.00	12.50	13.00	13.50	24.00

AREAS OF FLAT ROLLED BARS.

(CONTINUED.)

Thickness in Inches.	7″	7¼″	7½″	7¾″	8″	8¼″	8½″	8¾″	12″
1/16	.438	.453	.469	.484	.500	.516	.531	.547	.750
1/8	.875	.906	.938	.969	1.00	1.03	1.06	1.09	1.50
3/16	1.31	1.36	1.41	1.45	1.50	1.55	1.59	1.64	2.25
1/4	1.75	1.81	1.88	1.94	2.00	2.06	2.13	2.19	3.00
5/16	2.19	2.27	2.34	2.42	2.50	2.58	2.66	2.73	3.75
3/8	2.63	2.72	2.81	2.91	3.00	3.09	3.19	3.28	4.50
7/16	3.06	3.17	3.28	3.39	3.50	3.61	3.72	3.83	5.25
1/2	3.50	3.63	3.75	3.88	4.00	4.13	4.25	4.38	6.00
9/16	3.94	4.08	4.22	4.36	4.50	4.64	4.78	4.92	6.75
5/8	4.38	4.53	4.69	4.84	5.00	5.16	5.31	5.47	7.50
11/16	4.81	4.98	5.16	5.33	5.50	5.67	5.84	6.02	8.25
3/4	5.25	5.44	5.63	5.81	6.00	6.19	6.38	6.56	9.00
13/16	5.69	5.89	6.09	6.30	6.50	6.70	6.91	7.11	9.75
7/8	6.13	6.34	6.56	6.78	7.00	7.22	7.44	7.66	10.50
15/16	6.56	6.80	7.03	7.27	7.50	7.73	7.97	8.20	11.25
1	7.00	7.25	7.50	7.75	8.00	8.25	8.50	8.75	12.00
1 1/16	7.44	7.70	7.97	8.23	8.50	8.77	9.03	9.30	12.75
1 1/8	7.88	8.16	8.44	8.72	9.00	9.28	9.56	9.84	13.50
1 3/16	8.31	8.61	8.91	9.20	9.50	9.80	10.09	10.39	14.25
1 1/4	8.75	9.06	9.38	9.69	10.00	10.31	10.63	10.94	15.00
1 5/16	9.19	9.52	9.84	10.17	10.50	10.83	11.16	11.48	15.75
1 3/8	9.63	9.97	10.31	10.66	11.00	11.34	11.69	12.03	16.50
1 7/16	10.06	10.42	10.78	11.14	11.50	11.86	12.22	12.58	17.25
1 1/2	10.50	10.88	11.25	11.63	12.00	12.38	12.75	13.13	18.00
1 9/16	10.94	11.33	11.72	12.11	12.50	12.89	13.28	13.67	18.75
1 5/8	11.38	11.78	12.19	12.59	13.00	13.41	13.81	14.22	19.50
1 11/16	11.81	12.23	12.66	13.08	13.50	13.92	14.34	14.77	20.25
1 3/4	12.25	12.69	13.13	13.56	14.00	14.44	14.88	15.31	21.00
1 13/16	12.69	13.14	13.59	14.05	14.50	14.95	15.41	15.86	21.75
1 7/8	13.13	13.59	14.06	14.53	15.00	15.47	15.94	16.41	22.50
1 15/16	13.56	14.05	14.53	15.02	15.50	15.98	16.47	16.95	23.25
2	14.00	14.50	15.00	15.50	16.00	16.50	17.00	17.50	24.00

AREAS OF FLAT ROLLED BARS.

(CONTINUED.)

Thickness in Inches.	9″	9¼″	9½″	9¾″	10″	10¼″	10½″	10¾″	12″
$\frac{1}{16}$	.563	.578	.594	.609	.625	.641	.656	.672	.750
$\frac{1}{8}$	1.13	1.16	1.19	1.22	1.25	1.28	1.31	1.34	1.50
$\frac{3}{16}$	1.69	1.73	1.78	1.83	1.88	1.92	1.97	2.02	2.25
$\frac{1}{4}$	2.25	2.31	2.38	2.44	2.50	2.56	2.63	2.69	3.00
$\frac{5}{16}$	2.81	2.89	2.97	3.05	3.13	3.20	3.28	3.36	3.75
$\frac{3}{8}$	3.38	3.47	3.56	3.66	3.75	3.84	3.94	4.03	4.50
$\frac{7}{16}$	3.94	4.05	4.16	4.27	4.38	4.48	4.59	4.70	5.25
$\frac{1}{2}$	4.50	4.63	4.75	4.88	5.00	5.13	5.25	5.38	6.00
$\frac{9}{16}$	5.06	5.20	5.34	5.48	5.63	5.77	5.91	6.05	6.75
$\frac{5}{8}$	5.63	5.78	5.94	6.09	6.25	6.41	6.56	6.72	7.50
$\frac{11}{16}$	6.19	6.36	6.53	6.70	6.88	7.05	7.22	7.39	8.25
$\frac{3}{4}$	6.75	6.94	7.13	7.31	7.50	7.69	7.88	8.06	9.00
$\frac{13}{16}$	7.31	7.52	7.72	7.92	8.13	8.33	8.53	8.73	9.75
$\frac{7}{8}$	7.88	8.09	8.31	8.53	8.75	8.97	9.19	9.41	10.50
$\frac{15}{16}$	8.44	8.67	8.91	9.14	9.38	9.61	9.84	10.08	11.25
1	9.00	9.25	9.50	9.75	10.00	10.25	10.50	10.75	12.00
$1\frac{1}{16}$	9.56	9.83	10.09	10.36	10.63	10.89	11.16	11.42	12.75
$1\frac{1}{8}$	10.13	10.41	10.69	10.97	11.25	11.53	11.81	12.09	13.50
$1\frac{3}{16}$	10.69	10.98	11.28	11.58	11.88	12.17	12.47	12.77	14.25
$1\frac{1}{4}$	11.25	11.56	11.88	12.19	12.50	12.81	13.13	13.44	15.00
$1\frac{5}{16}$	11.81	12.14	12.47	12.80	13.13	13.45	13.78	14.11	15.75
$1\frac{3}{8}$	12.38	12.72	13.06	13.41	13.75	14.09	14.44	14.78	16.50
$1\frac{7}{16}$	12.94	13.30	13.66	14.02	14.38	14.73	15.09	15.45	17.25
$1\frac{1}{2}$	13.50	13.88	14.25	14.63	15.00	15.38	15.75	16.13	18.00
$1\frac{9}{16}$	14.06	14.45	14.84	15.23	15.63	16.02	16.41	16.80	18.75
$1\frac{5}{8}$	14.63	15.03	15.44	15.84	16.25	16.66	17.06	17.47	19.50
$1\frac{11}{16}$	15.19	15.61	16.03	16.45	16.88	17.30	17.72	18.14	20.25
$1\frac{3}{4}$	15.75	16.19	16.63	17.06	17.50	17.94	18.38	18.81	21.00
$1\frac{13}{16}$	16.31	16.77	17.22	17.67	18.13	18.58	19.03	19.48	21.75
$1\frac{7}{8}$	16.88	17.34	17.81	18.28	18.75	19.22	19.69	20.16	22.50
$1\frac{15}{16}$	17.44	17.92	18.41	18.89	19.38	19.86	20.34	20.83	23.25
2	18.00	18.50	19.00	19.50	20.00	20.50	21.00	21.50	24.00

AREAS OF FLAT ROLLED BARS.

(CONTINUED.)

Thickness in Inches.	11″	11¼″	11½″	11¾″	12″	12¼″	12½″	12¾″
$\frac{1}{16}$	.688	.703	.719	.734	.750	.766	.781	.797
$\frac{1}{8}$	1.38	1.41	1.44	1.47	1.50	1.53	1.56	1.59
$\frac{3}{16}$	2.06	2.11	2.16	2.20	2.25	2.30	2.34	2.39
$\frac{1}{4}$	2.75	2.81	2.88	2.94	3.00	3.06	3.13	3.19
$\frac{5}{16}$	3.44	3.52	3.59	3.67	3.75	3.83	3.91	3.98
$\frac{3}{8}$	4.13	4.22	4.31	4.41	4.50	4.59	4.69	4.78
$\frac{7}{16}$	4.81	4.92	5.03	5.14	5.25	5.36	5.47	5.58
$\frac{1}{2}$	5.50	5.63	5.75	5.88	6.00	6.13	6.25	6.38
$\frac{9}{16}$	6.19	6.33	6.47	6.61	6.75	6.89	7.03	7.17
$\frac{5}{8}$	6.88	7.03	7.19	7.34	7.50	7.66	7.81	7.97
$\frac{11}{16}$	7.56	7.73	7.91	8.08	8.25	8.42	8.59	8.77
$\frac{3}{4}$	8.25	8.44	8.63	8.81	9.00	9.19	9.38	9.56
$\frac{13}{16}$	8.94	9.14	9.34	9.55	9.75	9.95	10.16	10.36
$\frac{7}{8}$	9.63	9.84	10.06	10.28	10.50	10.72	10.94	11.16
$\frac{15}{16}$	10.31	10.55	10.78	11.02	11.25	11.48	11.72	11.95
1	11.00	11.25	11.50	11.75	12.00	12.25	12.50	12.75
$1\frac{1}{16}$	11.69	11.95	12.22	12.48	12.75	13.02	13.28	13.55
$1\frac{1}{8}$	12.38	12.66	12.94	13.22	13.50	13.78	14.06	14.34
$1\frac{3}{16}$	13.06	13.36	13.66	13.95	14.25	14.55	14.84	15.14
$1\frac{1}{4}$	13.75	14.06	14.38	14.69	15.00	15.31	15.63	15.94
$1\frac{5}{16}$	14.44	14.77	15.09	15.42	15.75	16.08	16.41	16.73
$1\frac{3}{8}$	15.13	15.47	15.81	16.16	16.50	16.84	17.19	17.53
$1\frac{7}{16}$	15.81	16.17	16.53	16.89	17.25	17.61	17.97	18.33
$1\frac{1}{2}$	16.50	16.88	17.25	17.63	18.00	18.38	18.75	19.13
$1\frac{9}{16}$	17.19	17.58	17.97	18.36	18.75	19.14	19.53	19.92
$1\frac{5}{8}$	17.88	18.28	18.69	19.09	19.50	19.91	20.31	20.72
$1\frac{11}{16}$	18.56	18.98	19.41	19.83	20.25	20.67	21.09	21.52
$1\frac{3}{4}$	19.25	19.69	20.13	20.56	21.00	21.44	21.88	22.31
$1\frac{13}{16}$	19.94	20.39	20.84	21.30	21.75	22.20	22.66	23.11
$1\frac{7}{8}$	20.63	21.09	21.56	22.03	22.50	22.97	23.44	23.91
$1\frac{15}{16}$	21.31	21.80	22.28	22.77	23.25	23.73	24.22	24.70
2	22.00	22.50	23.00	23.50	24.00	24.50	25.00	25.50

The areas for 12″ width are repeated on each page to facilitate making the additions necessary to obtain the areas of plates wider than 12″. Thus, to find the area of 15¼″ × ⅞″, add the areas to be found in the same line for 3¼ × ⅞ and 12 × ⅞ = 2.84 + 10.50 = 13.34 square inches.

WEIGHTS OF FLAT ROLLED BARS.

PER LINEAL FOOT.

For thicknesses from $\frac{3}{16}$ in. to 2 in. and Widths from 1 in. to 12¾ in.

Thickness in inches.	1″	1¼″	1½″	1¾″	2″	2¼″	2½″	2¾″	12″
$\frac{3}{16}$	.638	.797	.957	1.11	1.28	1.44	1.59	1.75	7.65
¼	.850	1.06	1.28	1.49	1.70	1.91	2.12	2.34	10.20
$\frac{5}{16}$	1.06	1.33	1.59	1.86	2.12	2.39	2.65	2.92	12.75
⅜	1.28	1.59	1.92	2.23	2.55	2.87	3.19	3.51	15.30
$\frac{7}{16}$	1.49	1.86	2.23	2.60	2.98	3.35	3.72	4.09	17.85
½	1.70	2.12	2.55	2.98	3.40	3.83	4.25	4.67	20.40
$\frac{9}{16}$	1.92	2.39	2.87	3.35	3.83	4.30	4.78	5.26	22.95
⅝	2.12	2.65	3.19	3.72	4.25	4.78	5.31	5.84	25.50
$\frac{11}{16}$	2.34	2.92	3.51	4.09	4.67	5.26	5.84	6.43	28.05
¾	2.55	3.19	3.83	4.47	5.10	5.75	6.38	7.02	30.60
$\frac{13}{16}$	2.76	3.45	4.14	4.84	5.53	6.21	6.90	7.60	33.15
⅞	2.98	3.72	4.47	5.20	5.95	6.69	7.44	8.18	35.70
$\frac{15}{16}$	3.19	3.99	4.78	5.58	6.38	7.18	7.97	8.77	38.25
1	3.40	4.25	5.10	5.95	6.80	7.65	8.50	9.35	40.80
$1\frac{1}{16}$	3.61	4.52	5.42	6.32	7.22	8.13	9.03	9.93	43.35
1⅛	3.83	4.78	5.74	6.70	7.65	8.61	9.57	10.52	45.90
$1\frac{3}{16}$	4.04	5.05	6.06	7.07	8.08	9.09	10.10	11.11	48.45
1¼	4.25	5.31	6.38	7.44	8.50	9.57	10.63	11.69	51.00
$1\frac{5}{16}$	4.46	5.58	6.69	7.81	8.93	10.04	11.16	12.27	53.55
1⅜	4.67	5.84	7.02	8.18	9.35	10.52	11.69	12.85	56.10
$1\frac{7}{16}$	4.89	6.11	7.34	8.56	9.78	11.00	12.22	13.44	58.65
1½	5.10	6.38	7.65	8.93	10.20	11.48	12.75	14.03	61.20
$1\frac{9}{16}$	5.32	6.64	7.97	9.30	10.63	11.95	13.28	14.61	63.75
1⅝	5.52	6.90	8.29	9.67	11.05	12.43	13.81	15.19	66.30
$1\frac{11}{16}$	5.74	7.17	8.61	10.04	11.47	12.91	14.34	15.78	68.85
1¾	5.95	7.44	8.93	10.42	11.90	13.40	14.88	16.37	71.40
$1\frac{13}{16}$	6.16	7.70	9.24	10.79	12.33	13.86	15.40	16.95	73.95
1⅞	6.38	7.97	9.57	11.15	12.75	14.34	15.94	17.53	76.50
$1\frac{15}{16}$	6.59	8.24	9.88	11.53	13.18	14.83	16.47	18.12	79.05
2	6.80	8.50	10.20	11.90	13.60	15.30	17.00	18.70	81.60

WEIGHTS OF FLAT ROLLED BARS.

PER LINEAL FOOT.

(CONTINUED.)

Thickness in inches.	3″	3¼″	3½″	3¾″	4″	4¼″	4½″	4¾″	12″
$\frac{3}{16}$	1.91	2.07	2.23	2.39	2.55	2.71	2.87	3.03	7.65
¼	2.55	2.76	2.98	3.19	3.40	3.61	3.83	4.04	10.20
$\frac{5}{16}$	3.19	3.45	3.72	3.99	4.25	4.52	4.78	5.05	12.75
⅜	3.83	4.15	4.47	4.78	5.10	5.42	5.74	6.06	15.30
$\frac{7}{16}$	4.46	4.83	5.20	5.58	5.95	6.32	6.70	7.07	17.85
½	5.10	5.53	5.95	6.38	6.80	7.22	7.65	8.08	20.40
$\frac{9}{16}$	5.74	6.22	6.70	7.17	7.65	8.13	8.61	9.09	22.95
⅝	6.38	6.91	7.44	7.97	8.50	9.03	9.57	10.10	25.50
$\frac{11}{16}$	7.02	7.60	8.18	8.76	9.35	9.93	10.52	11.11	28.05
¾	7.65	8.29	8.93	9.57	10.20	10.84	11.48	12.12	30.60
$\frac{13}{16}$	8.29	8.98	9.67	10.36	11.05	11.74	12.43	13.12	33.15
⅞	8.93	9.67	10.41	11.16	11.90	12.65	13.39	14.13	35.70
$\frac{15}{16}$	9.57	10.36	11.16	11.95	12.75	13.55	14.34	15.14	38.25
1	10.20	11.05	11.90	12.75	13.60	14.45	15.30	16.15	40.80
$1\frac{1}{16}$	10.84	11.74	12.65	13.55	14.45	15.35	16.26	17.16	43.35
1⅛	11.48	12.43	13.39	14.34	15.30	16.26	17.22	18.17	45.90
$1\frac{3}{16}$	12.12	13.12	14.13	15.14	16.15	17.16	18.17	19.18	48.45
1¼	12.75	13.81	14.87	15.94	17.00	18.06	19.13	20.19	51.00
$1\frac{5}{16}$	13.39	14.50	15.62	16.74	17.85	18.96	20.08	21.20	53.55
1⅜	14.03	15.20	16.36	17.53	18.70	19.87	21.04	22.21	56.10
$1\frac{7}{16}$	14.66	15.88	17.10	18.33	19.55	20.77	21.99	23.22	58.65
1½	15.30	16.58	17.85	19.13	20.40	21.68	22.95	24.23	61.20
$1\frac{9}{16}$	15.94	17.27	18.60	19.92	21.25	22.58	23.91	25.24	63.75
1⅝	16.58	17.96	19.34	20.72	22.10	23.48	24.87	26.25	66.30
$1\frac{11}{16}$	17.22	18.65	20.08	21.51	22.95	24.38	25.82	27.26	68.85
1¾	17.85	19.34	20.83	22.32	23.80	25.29	26.78	28.27	71.40
$1\frac{13}{16}$	18.49	20.03	21.57	23.11	24.65	26.19	27.73	29.27	73.95
1⅞	19.13	20.72	22.31	23.91	25.50	27.10	28.69	30.28	76.50
$1\frac{15}{16}$	19.77	21.41	23.06	24.70	26.35	28.00	29.64	31.29	79.05
2	20.40	22.10	23.80	25.50	27.20	28.90	30.60	32.30	81.60

WEIGHTS OF FLAT ROLLED BARS.

PER LINEAL FOOT.

(CONTINUED.)

Thickness in inches.	5″	5¼″	5½″	5¾″	6″	6¼″	6½″	6¾″	12″
$\frac{3}{16}$	3.19	3.35	3.51	3.67	3.83	3.99	4.14	4.30	7.65
¼	4.25	4.46	4.67	4.89	5.10	5.31	5.53	5.74	10.20
$\frac{5}{16}$	5.31	5.58	5.84	6.11	6.38	6.64	6.90	7.17	12.75
⅜	6.38	6.69	7.02	7.34	7.65	7.97	8.29	8.61	15.30
$\frac{7}{16}$	7.44	7.81	8.18	8.56	8.93	9.29	9.67	10.04	17.85
½	8.50	8.93	9.35	9.77	10.20	10.63	11.05	11.48	20.40
$\frac{9}{16}$	9.57	10.04	10.52	11.00	11.48	11.95	12.43	12.91	22.95
⅝	10.63	11.16	11.69	12.22	12.75	13.28	13.81	14.34	25.50
$\frac{11}{16}$	11.69	12.27	12.85	13.44	14.03	14.61	15.20	15.78	28.05
¾	12.75	13.39	14.03	14.67	15.30	15.94	16.58	17.22	30.60
$\frac{13}{16}$	13.81	14.50	15.19	15.88	16.58	17.27	17.95	18.65	33.15
⅞	14.87	15.62	16.36	17.10	17.85	18.60	19.34	20.08	35.70
$\frac{15}{16}$	15.94	16.74	17.53	18.33	19.13	19.92	20.72	21.51	38.25
1	17.00	17.85	18.70	19.55	20.40	21.25	22.10	22.95	40.80
1$\frac{1}{16}$	18.06	18.96	19.87	20.77	21.68	22.58	23.48	24.39	43.35
1⅛	19.13	20.08	21.04	21.99	22.95	23.91	24.87	25.82	45.90
1$\frac{3}{16}$	20.19	21.20	22.21	23.22	24.23	25.23	26.24	27.25	48.45
1¼	21.25	22.32	23.38	24.44	25.50	26.56	27.62	28.69	51.00
1$\frac{5}{16}$	22.32	23.43	24.54	25.66	26.78	27.90	29.01	30.12	53.55
1⅜	23.38	24.54	25.71	26.88	28.05	29.22	30.39	31.56	56.10
1$\frac{7}{16}$	24.44	25.66	26.88	28.10	29.33	30.55	31.77	32.99	58.65
1½	25.50	26.78	28.05	29.33	30.60	31.88	33.15	34.43	61.20
1$\frac{9}{16}$	26.57	27.89	29.22	30.55	31.88	33.20	34.53	35.86	63.75
1⅝	27.63	29.01	30.39	31.77	33.15	34.53	35.91	37.29	66.30
1$\frac{11}{16}$	28.69	30.12	31.55	32.99	34.43	35.86	37.30	38.73	68.85
1¾	29.75	31.24	32.73	34.22	35.70	37.19	38.68	40.17	71.40
1$\frac{13}{16}$	30.81	32.35	33.89	35.43	36.98	38.52	40.05	41.60	73.95
1⅞	31.87	33.47	35.06	36.65	38.25	39.85	41.44	43.03	76.50
1$\frac{15}{16}$	32.94	34.59	36.23	37.88	39.53	41.17	42.82	44.46	79.05
2	34.00	35.70	37.40	39.10	40.80	42.50	44.20	45.90	81.60

WEIGHTS OF FLAT ROLLED BARS.

PER LINEAL FOOT.

(CONTINUED.)

Thickness in inches.	7″	7¼″	7½″	7¾″	8″	8¼″	8½″	8¾″	12″
3/16	4.46	4.62	4.78	4.94	5.10	5.26	5.42	5.58	7.65
¼	5.95	6.16	6.36	6.58	6.80	7.01	7.22	7.43	10.20
5/16	7.44	7.70	7.97	8.23	8.50	8.76	9.03	9.29	12.75
⅜	8.93	9.25	9.57	9.88	10.20	10.52	10.84	11.16	15.30
7/16	10.41	10.78	11.16	11.53	11.90	12.27	12.64	13.02	17.85
½	11.90	12.32	12.75	13.18	13.60	14.03	14.44	14.87	20.40
9/16	13.39	13.86	14.34	14.82	15.30	15.78	16.26	16.74	22.95
⅝	14.87	15.40	15.94	16.47	17.00	17.53	18.06	18.59	25.50
11/16	16.36	16.94	17.53	18.12	18.70	19.28	19.86	20.45	28.05
¾	17.85	18.49	19.13	19.77	20.40	21.04	21.68	22.32	30.60
13/16	19.34	20.03	20.72	21.41	22.10	22.79	23.48	24.17	33.15
⅞	20.83	21.57	22.32	23.05	23.80	24.55	25.30	26.04	35.70
15/16	22.32	23.11	23.91	24.70	25.50	26.30	27.10	27.89	38.25
1	23.80	24.65	25.50	26.35	27.20	28.05	28.90	29.75	40.80
1 1/16	25.29	26.19	27.10	28.00	28.90	29.80	30.70	31.61	43.35
1⅛	26.78	27.73	28.68	29.64	30.60	31.56	32.52	33.47	45.90
1 3/16	28.26	29.27	30.28	31.29	32.30	33.31	34.32	35.33	48.45
1¼	29.75	30.81	31.88	32.94	34.00	35.06	36.12	37.20	51.00
1 5/16	31.23	32.35	33.48	34.59	35.70	36.81	37.93	39.05	53.55
1⅜	32.72	33.89	35.06	36.23	37.40	38.57	39.74	40.91	56.10
1 7/16	34.21	35.44	36.66	37.88	39.10	40.32	41.54	42.77	58.65
1½	35.70	36.98	38.26	39.53	40.80	42.08	43.35	44.63	61.20
1 9/16	37.19	38.51	39.84	41.17	42.50	43.83	45.16	46.49	63.75
1⅝	38.67	40.05	41.44	42.82	44.20	45.58	46.96	48.34	66.30
1 11/16	40.16	41.59	43.03	44.47	45.90	47.33	48.76	50.20	68.85
1¾	41.65	43.14	44.63	46.12	47.60	49.09	50.58	52.07	71.40
1 13/16	43.14	44.68	46.22	47.76	49.30	50.84	52.38	53.92	73.95
1⅞	44.63	46.22	47.82	49.40	51.00	52.60	54.20	55.79	76.50
1 15/16	46.12	47.76	49.41	51.05	52.70	54.35	56.00	57.64	79.05
2	47.60	49.30	51.00	52.70	54.40	56.10	57.80	59.50	81.60

WEIGHTS OF FLAT ROLLED BARS.

PER LINEAL FOOT.

(CONTINUED.)

Thickness in inches.	9″	9¼″	9½″	9¾″	10″	10¼″	10½″	10¾″	12″
3/16	5.74	5.90	6.06	6.22	6.38	6.54	6.70	6.86	7.65
1/4	7.65	7.86	8.08	8.29	8.50	8.71	8.92	9.14	10.20
5/16	9.56	9.83	10.10	10.36	10.62	10.89	11.16	11.42	12.75
3/8	11.48	11.80	12.12	12.44	12.75	13.07	13.39	13.71	15.30
7/16	13.40	13.76	14.14	14.51	14.88	15.25	15.62	15.99	17.85
1/2	15.30	15.73	16.16	16.58	17.00	17.42	17.85	18.28	20.40
9/16	17.22	17.69	18.18	18.65	19.14	19.61	20.08	20.56	22.95
5/8	19.13	19.65	20.19	20.72	21.25	21.78	22.32	22.85	25.50
11/16	21.04	21.62	22.21	22.79	23.38	23.96	24.54	25.13	28.05
3/4	22.96	23.59	24.23	24.86	25.50	26.14	26.78	27.42	30.60
13/16	24.86	25.55	26.24	26.94	27.62	28.32	29.00	29.69	33.15
7/8	26.78	27.52	28.26	29.01	29.75	30.50	31.24	31.98	35.70
15/16	28.69	29.49	30.28	31.08	31.88	32.67	33.48	34.28	38.25
1	30.60	31.45	32.30	33.15	34.00	34.85	35.70	36.55	40.80
1 1/16	32.52	33.41	34.32	35.22	36.12	37.03	37.92	38.83	43.35
1 1/8	34.43	35.38	36.34	37.29	38.25	39.21	40.17	41.12	45.90
1 3/16	36.34	37.35	38.36	39.37	40.38	41.39	42.40	43.40	48.45
1 1/4	38.26	39.31	40.37	41.44	42.50	43.56	44.63	45.69	51.00
1 5/16	40.16	41.28	42.40	43.52	44.64	45.75	46.86	47.97	53.55
1 3/8	42.08	43.25	44.41	45.58	46.75	47.92	49.08	50.25	56.10
1 7/16	44.00	45.22	46.44	47.66	48.88	50.10	51.32	52.54	58.65
1 1/2	45.90	47.18	48.45	49.73	51.00	52.28	53.55	54.83	61.20
1 9/16	47.82	49.14	50.48	51.80	53.14	54.46	55.78	57.11	63.75
1 5/8	49.73	51.10	52.49	53.87	55.25	56.63	58.02	59.40	66.30
1 11/16	51.64	53.07	54.51	55.94	57.38	58.81	60.24	61.68	68.85
1 3/4	53.56	55.04	56.53	58.01	59.50	60.99	62.48	63.97	71.40
1 13/16	55.46	57.00	58.54	60.09	61.62	63.17	64.70	66.24	73.95
1 7/8	57.38	58.97	60.56	62.16	63.75	65.35	66.94	68.53	76.50
1 15/16	59.29	60.94	62.58	64.23	65.88	67.52	69.18	70.83	79.05
2	61.20	62.90	64.60	66.30	68.00	69.70	71.40	73.10	81.60

WEIGHTS OF FLAT ROLLED BARS.

PER LINEAL FOOT.

(CONTINUED.)

Thickness in inches.	11″	11¼″	11½″	11¾″	12″	12¼″	12½″	12¾″
3/16	7.02	7.17	7.32	7.49	7.65	7.82	7.98	8.13
¼	9.34	9.57	9.78	10.00	10.20	10.42	10.63	10.84
5/16	11.68	11.95	12.22	12.49	12.75	13.01	13.28	13.55
⅜	14.03	14.35	14.68	14.99	15.30	15.62	15.94	16.26
7/16	16.36	16.74	17.12	17.49	17.85	18.23	18.60	18.97
½	18.70	19.13	19.55	19.97	20.40	20.82	21.25	21.67
9/16	21.02	21.51	22.00	22.48	22.95	23.43	23.90	24.39
⅝	23.38	23.91	24.44	24.97	25.50	26.03	26.56	27.09
11/16	25.70	26.30	26.88	27.47	28.05	28.64	29.22	29.80
¾	28.05	28.68	29.33	29.97	30.60	31.25	31.88	32.52
13/16	30.40	31.08	31.76	32.46	33.15	33.83	34.53	35.22
⅞	32.72	33.47	34.21	34.95	35.70	36.44	37.19	37.93
15/16	35.06	35.86	36.66	37.46	38.25	39.05	39.84	40.64
1	37.40	38.25	39.10	39.95	40.80	41.65	42.50	43.35
1 1/16	39.74	40.64	41.54	42.45	43.35	44.25	45.16	46.06
1⅛	42.08	43.04	44.00	44.94	45.90	46.86	47.82	48.77
1 3/16	44.42	45.42	46.44	47.45	48.45	49.46	50.46	51.48
1¼	46.76	47.82	48.88	49.94	51.00	52.06	53.12	54.19
1 5/16	49.08	50.20	51.32	52.44	53.55	54.67	55.78	56.90
1⅜	51.42	52.59	53.76	54.93	56.10	57.27	58.44	59.60
1 7/16	53.76	54.99	56.21	57.43	58.65	59.87	61.10	62.32
1½	56.10	57.37	58.65	59.93	61.20	62.48	63.75	65.03
1 9/16	58.42	59.76	61.10	62.43	63.75	65.08	66.40	67.74
1⅝	60.78	62.16	63.54	64.92	66.30	67.68	69.06	70.44
1 11/16	63.10	64.55	65.98	67.42	68.85	70.29	71.72	73.15
1¾	65.45	66.93	68.43	69.92	71.40	72.90	74.38	75.87
1 13/16	67.80	69.33	70.86	72.41	73.95	75.48	77.03	78.57
1⅞	70.12	71.72	73.31	74.90	76.50	78.09	79.69	81.28
1 15/16	72.46	74.11	75.76	77.41	79.05	80.70	82.34	83.99
2	74.80	76.50	78.20	79.90	81.60	83.30	85.00	86.70

The weights for 12″ width are repeated on each page to facilitate making the additions necessary to obtain the weights of plates wider than 12″. Thus to find the weight of 15½″×⅞″, add the weights to be found in the same line for 3½×⅞ and 12×⅞ = 10.41 + 35.70 = 46.11 lbs.

WEIGHTS AND AREAS OF SQUARE AND ROUND BARS AND CIRCUMFERENCES OF ROUND BARS.

One cubic foot weighing 490 lbs.

Thickness or Diameter in Inches.	Weight of □ Bar One Foot long.	Weight of ○ Bar One Foot long.	Area of □ Bar in sq. inches.	Area of ○ Bar in sq. inches.	Circumference of ○ Bar in inches.
0					
1/16	.013	.010	.0039	.0031	.1963
1/8	.053	.042	.0156	.0123	.3927
3/16	.119	.094	.0352	.0276	.5890
1/4	.212	.167	.0625	.0491	.7854
5/16	.333	.261	.0977	.0767	.9817
3/8	.478	.375	.1406	.1104	1.1781
7/16	.651	.511	.1914	.1503	1.3744
1/2	.850	.667	.2500	.1963	1.5708
9/16	1.076	.845	.3164	.2485	1.7671
5/8	1.328	1.043	.3906	.3068	1.9635
11/16	1 608	1.262	.4727	.3712	2.1598
3/4	1.913	1.502	.5625	.4418	2.3562
13/16	2.245	1.763	.6602	.5185	2.5525
7/8	2.603	2.044	.7656	.6013	2.7489
15/16	2.989	2.347	.8789	.6903	2.9452
1	3.400	2.670	1.0000	.7854	3.1416
1/16	3.838	3.014	1.1289	.8866	3.3379
1/8	4.303	3.379	1.2656	.9940	3.5343
3/16	4.795	3.766	1.4102	1.1075	3.7306
1/4	5.312	4.173	1.5625	1.2272	3.9270
5/16	5.857	4.600	1.7227	1.3530	4.1233
3/8	6.428	5.049	1.8906	1.4849	4.3197
7/16	7.026	5.518	2.0664	1.6230	4.5160
1/2	7.650	6.008	2.2500	1.7671	4.7124
9/16	8.301	6.520	2.4414	1.9175	4.9087
5/8	8.978	7.051	2.6406	2.0739	5.1051
11/16	9.682	7.604	2.8477	2.2365	5.3014
3/4	10.41	8.178	3.0625	2.4053	5.4978
13/16	11.17	8.773	3.2852	2.5802	5.6941
7/8	11.95	9.388	3.5156	2.7612	5.8905
15/16	12.76	10.02	3.7539	2.9483	6.0868

SQUARE AND ROUND BARS.

(CONTINUED.)

Thickness or Diameter in Inches.	Weight of □ Bar One Foot long.	Weight of ○ Bar One Foot long.	Area of □ Bar in sq. inches.	Area of ○ Bar in sq. inches.	Circumference of ○ Bar in inches.
2	13.60	10.68	4.0000	3.1416	6.2832
$\frac{1}{16}$	14.46	11.36	4.2539	3.3410	6.4795
$\frac{1}{8}$	15.35	12.06	4.5156	3.5466	6.6759
$\frac{3}{16}$	16.27	12.78	4.7852	3.7583	6.8722
$\frac{1}{4}$	17.22	13.52	5.0625	3.9761	7.0686
$\frac{5}{16}$	18.19	14.28	5.3477	4.2000	7.2649
$\frac{3}{8}$	19.18	15.07	5.6406	4.4301	7.4613
$\frac{7}{16}$	20.20	15.86	5.9414	4.6664	7.6576
$\frac{1}{2}$	21.25	16.69	6.2500	4.9087	7.8540
$\frac{9}{16}$	22.33	17.53	6.5664	5.1572	8.0503
$\frac{5}{8}$	23.43	18.40	6.8906	5.4119	8.2467
$\frac{11}{16}$	24.56	19.29	7.2227	5.6727	8.4430
$\frac{3}{4}$	25	20.20	7.5625	5.9396	8.6394
$\frac{13}{16}$	26.90	21.12	7.9102	6.2126	8.8357
$\frac{7}{8}$	28.10	22.07	8.2656	6.4918	9.0321
$\frac{15}{16}$	29.34	23.04	8.6289	6.7771	9.2284
3	30 60	24.03	9.0000	7.0686	9.4248
$\frac{1}{16}$	31.89	25.04	9.3789	7.3662	9.6211
$\frac{1}{8}$	33.20	26.08	9.7656	7.6699	9.8175
$\frac{3}{16}$	34.55	27.13	10.160	7.9798	10.014
$\frac{1}{4}$	35.92	28.20	10.563	8.2958	10.210
$\frac{5}{16}$	37.31	29.30	10.973	8.6179	10.407
$\frac{3}{8}$	38.73	30.42	11.391	8.9462	10.603
$\frac{7}{16}$	40.18	31.56	11.816	9.2806	10.799
$\frac{1}{2}$	41.65	32.71	12.250	9.6211	10.996
$\frac{9}{16}$	43.14	33.90	12.691	9.9678	11.192
$\frac{5}{8}$	44.68	35.09	13.141	10.321	11.388
$\frac{11}{16}$	46.24	36.31	13.598	10.680	11.585
$\frac{3}{4}$	47.82	37.56	14.063	11.045	11.781
$\frac{13}{16}$	49.42	38.81	14.535	11.416	11.977
$\frac{7}{8}$	51.05	40.10	15.016	11.793	12.174
$\frac{15}{16}$	52.71	41.40	15.504	12.177	12.370

SQUARE AND ROUND BARS.

(CONTINUED.)

Thickness or Diameter in Inches.	Weight of □ Bar One Foot long.	Weight of ○ Bar One Foot long.	Area of □ Bar in sq. inches.	Area of ○ Bar in sq. inches.	Circumference of ○ Bar in inches.
4	54.40	42.73	16.000	12.566	12.566
$\frac{1}{16}$	56.11	44.07	16.504	12.962	12.763
$\frac{1}{8}$	57.85	45.44	17.016	13.364	12.959
$\frac{3}{16}$	59.62	46.83	17.535	13.772	13.155
$\frac{1}{4}$	61.41	48.24	18.063	14.186	13.352
$\frac{5}{16}$	63.23	49.66	18.598	14.607	13.548
$\frac{3}{8}$	65.08	51.11	19.141	15.033	13.744
$\frac{7}{16}$	66.95	52.58	19.691	15.466	13.941
$\frac{1}{2}$	68.85	54.07	20.250	15.904	14.137
$\frac{9}{16}$	70.78	55.59	20.816	16.349	14.334
$\frac{5}{8}$	72.73	57.12	21.391	16.800	14.530
$\frac{11}{16}$	74.70	58.67	21.973	17.257	14.726
$\frac{3}{4}$	76.71	60.25	22.563	17.721	14.923
$\frac{13}{16}$	78.74	61.84	23.160	18.190	15.119
$\frac{7}{8}$	80.81	63.46	23.766	18.665	15.315
$\frac{15}{16}$	82.89	65.10	24.379	19.147	15.512
5	85.00	66.76	25.000	19.635	15.708
$\frac{1}{16}$	87.14	68.44	25.629	20.129	15.904
$\frac{1}{8}$	89.30	70.14	26.266	20.629	16.101
$\frac{3}{16}$	91.49	71.86	26.910	21.135	16.297
$\frac{1}{4}$	93.72	73.60	27.563	21.648	16.493
$\frac{5}{16}$	95.96	75.37	28.223	22.166	16.690
$\frac{3}{8}$	98.23	77.15	28.891	22.691	16.886
$\frac{7}{16}$	100.5	78.95	29.566	23.221	17.082
$\frac{1}{2}$	102.8	80.77	30.250	23.758	17.279
$\frac{9}{16}$	105.2	82.62	30.941	24.301	17.475
$\frac{5}{8}$	107.6	84.49	31.641	24.850	17.671
$\frac{11}{16}$	110.0	86.38	32.348	25.406	17.868
$\frac{3}{4}$	112.4	88.29	33.063	25.967	18.064
$\frac{13}{16}$	114.9	90.22	33.785	26.535	18.261
$\frac{7}{8}$	117.4	92.17	34.516	27.109	18.457
$\frac{15}{16}$	119.9	94.14	35.254	27.688	18.653

SQUARE AND ROUND BARS.

(CONTINUED.)

Thickness or Diameter in Inches.	Weight of □ Bar One Foot long.	Weight of ○ Bar One Foot long.	Area of □ Bar in sq. inches.	Area of ○ Bar in sq. inches.	Circumference of ○ Bar in inches.
6	122.4	96.14	36.000	28.274	18.850
1/16	125.0	98.14	36.754	28.866	19.046
1/8	127.6	100.2	37.516	29.465	19.242
3/16	130.2	102.2	38.285	30.069	19.439
1/4	132.8	104.3	39.063	30.680	19.635
5/16	135.5	106.4	39.848	31.296	19.831
3/8	138.2	108.5	40.641	31.919	20.028
7/16	140.9	110.7	41.441	32.548	20.224
1/2	143.6	112.8	42.250	33.183	20.420
9/16	146.5	114.9	43.066	33.824	20.617
5/8	149.2	117.2	43.891	34.472	20.813
11/16	152.1	119.4	44.723	35.125	21.009
3/4	154.9	121.7	45.563	35.785	21.206
13/16	157.8	123.9	46.410	36.450	21.402
7/8	160.8	126.2	47.266	37.122	21.598
15/16	163.6	128.5	48.129	37.800	21.795
7	166.6	130.9	49.000	38.485	21.991
1/16	169.6	133.2	49.879	39.175	22.187
1/8	172.6	135.6	50.766	39.871	22.384
3/16	175.6	137.9	51.660	40.574	22.580
1/4	178.7	140.4	52.563	41.282	22.777
5/16	181.8	142.8	53.473	41.997	22.973
3/8	184.9	145.3	54.391	42.718	23.169
7/16	188.1	147.7	55.316	43.445	23.366
1/2	191.3	150.2	56.250	44.179	23.562
9/16	194.4	152.7	57.191	44.918	23.758
5/8	197.7	155.2	58.141	45.664	23.955
11/16	200.9	157.8	59.098	46.415	24.151
3/4	204.2	160.3	60.063	47.173	24.347
13/16	207.6	163.0	61.035	47.937	24.544
7/8	210.8	165.6	62.016	48.707	24.740
15/16	214.2	168.2	63.004	49.483	24.936

SQUARE AND ROUND BARS.

(CONTINUED.)

Thickness or Diameter in Inches.	Weight of □ Bar One Foot long.	Weight of ○ Bar One Foot long.	Area of □ Bar in sq. inches.	Area of ○ Bar in sq. inches.	Circumference of ○ Bar in inches.
8	217.6	171.0	64.000	50.265	25.133
1/16	221.0	173.6	65.004	51.054	25.329
1/8	224.5	176.3	66.016	51.849	25.525
3/16	228.0	179.0	67.035	52.649	25.722
1/4	231.4	181.8	68.063	53.456	25.918
5/16	234.9	184.5	69.098	54.269	26.114
3/8	238.5	187.3	70.141	55.088	26.311
7/16	242.0	190.1	71.191	55.914	26.507
1/2	245.6	193.0	72.250	56.745	26.704
9/16	249.3	195.7	73.316	57.583	26.900
5/8	252.9	198.7	74.391	58.426	27.096
11/16	256.6	201.6	75.473	59.276	27.293
3/4	260.3	204.4	76.563	60.132	27.489
13/16	264.1	207.4	77.660	60.994	27.685
7/8	267.9	210.3	78.766	61.862	27.882
15/16	271.6	213.3	79.879	62.737	28.078
9	275.4	216.3	81.000	63.617	28.274
1/16	279.3	219.3	82.129	64.504	28.471
1/8	283.2	222.4	83.266	65.397	28.667
3/16	287.0	225.4	84.410	66.296	28.863
1/4	290.9	228.5	85.563	67.201	29.060
5/16	294.9	231.5	86.723	68.112	29.256
3/8	298.9	234.7	87.891	69.029	29.452
7/16	302.8	237.9	89.066	69.953	29.649
1/2	306.8	241.0	90.250	70.882	29.845
9/16	310.9	244.2	91.441	71.818	30.041
5/8	315.0	247.4	92.641	72.760	30.238
11/16	319.1	250.6	93.848	73.708	30.434
3/4	323.2	253.9	95.063	74.662	30.631
13/16	327.4	257.1	96.285	75.622	30.827
7/8	331.6	260.4	97.516	76.589	31.023
15/16	335.8	263.7	98.754	77.561	31.220

SQUARE AND ROUND BARS.

(CONTINUED.)

Thickness or Diameter in Inches.	Weight of □ Bar One Foot long.	Weight of ○ Bar One Foot long.	Area of □ Bar in sq. inches.	Area of ○ Bar in sq. inches.	Circumference of ○ Bar in inches.
10	340.0	267.0	100.00	78.540	31.416
$\frac{1}{16}$	344.3	270.4	101.25	79.525	31.612
$\frac{1}{8}$	348.5	273.8	102.52	80.516	31.809
$\frac{3}{16}$	352.9	277.1	103.79	81.513	32.005
$\frac{1}{4}$	357.2	280.6	105.06	82.516	32.201
$\frac{5}{16}$	361.6	284.0	106.35	83.525	32.398
$\frac{3}{8}$	366.0	287.4	107.64	84.541	32.594
$\frac{7}{16}$	370.4	290.9	108.94	85.562	32.790
$\frac{1}{2}$	374.9	294.4	110.25	86.590	32.987
$\frac{9}{16}$	379.4	297.9	111.57	87.624	33.183
$\frac{5}{8}$	383.8	301.4	112.89	88.664	33.379
$\frac{11}{16}$	388.3	305.0	114.22	89.710	33.576
$\frac{3}{4}$	392.9	308.6	115.56	90.763	33.772
$\frac{13}{16}$	397.5	312.2	116.91	91.821	33.968
$\frac{7}{8}$	402.1	315.8	118.27	92.886	34.165
$\frac{15}{16}$	406.8	319.5	119.63	93.956	34.361
11	411.4	323.1	121.00	95.033	34.558
$\frac{1}{16}$	416.1	326.8	122.38	96.116	34.754
$\frac{1}{8}$	420.9	330.5	123.77	97.205	34.950
$\frac{3}{16}$	425.5	334.3	125.16	98.301	35.147
$\frac{1}{4}$	430.3	337.9	126.56	99.402	35.343
$\frac{5}{16}$	435.1	341.7	127.97	100.51	35.539
$\frac{3}{8}$	439.9	345.5	129.39	101.62	35.736
$\frac{7}{16}$	444.8	349.4	130.82	102.74	35.932
$\frac{1}{2}$	449.6	353.1	132.25	103.87	36.128
$\frac{9}{16}$	454.5	357.0	133.69	105.00	36.325
$\frac{5}{8}$	459.5	360.9	135.14	106.14	36.521
$\frac{11}{16}$	464.4	364.8	136.60	107.28	36.717
$\frac{3}{4}$	469.4	368.6	138.06	108.43	36.914
$\frac{13}{16}$	474.4	372.6	139.54	109.59	37.110
$\frac{7}{8}$	479.5	376.6	141.02	110.75	37.306
$\frac{15}{16}$	484.5	380.6	142.50	111.92	37.503

WEIGHT OF RIVETS, and ROUND HEADED BOLTS WITHOUT NUTS, PER 100.

Length from under head. One cubic foot weighing 480 lbs.

Length. Inches.	3/8″ Dia.	1/2″ Dia.	5/8″ Dia.	3/4″ Dia.	7/8″ Dia.	1″ Dia.	1 1/8″ Dia.	1 1/4″ Dia.
1 1/4	5.4	12.6	21.5	28.7	43.1	65.3	91.5	123.
1 1/2	6.2	13.9	23.7	31.8	47.3	70.7	98.4	133.
1 3/4	6.9	15.3	25.8	34.9	51.4	76.2	105.	142.
2	7.7	16.6	27.9	37.9	55.6	81.6	112.	150.
2 1/4	8.5	18.0	30.0	41.0	59.8	87.1	119.	159.
2 1/2	9.2	19.4	32.2	44.1	63.0	92.5	126.	167.
2 3/4	10.0	20.7	34.3	47.1	68.1	98.0	133.	176.
3	10.8	22.1	36.4	50.2	72.3	103.	140.	184.
3 1/4	11.5	23.5	38.6	53.3	76.5	109.	147.	193.
3 1/2	12.3	24.8	40.7	56.4	80.7	114.	154.	201.
3 3/4	13.1	26.2	42.8	59.4	84.8	120.	161.	210.
4	13.8	27.5	45.0	62.5	89.0	125.	167.	218.
4 1/4	14.6	28.9	47.1	65.6	93.2	131.	174.	227.
4 1/2	15.4	30.3	49.2	68.6	97.4	136.	181.	236.
4 3/4	16.2	31.6	51.4	71.7	102.	142.	188.	244.
5	16.9	33.0	53.5	74.8	106.	147.	195.	253.
5 1/4	17.7	34.4	55.6	77.8	110.	153.	202.	261.
5 1/2	18.4	35.7	57.7	80.9	114.	158.	209.	270.
5 3/4	19.2	37.1	59.9	84.0	118.	163.	216.	278.
6	20.0	38.5	62.0	87.0	122.	169.	223.	287.
6 1/2	21.5	41.2	66.3	93.2	131.	180.	236.	304.
7	23.0	43.9	70.5	99.3	139.	191.	250.	321.
7 1/2	24.6	46.6	74.8	106.	147.	202.	264.	338.
8	26.1	49.4	79.0	112.	156.	213.	278.	355.
8 1/2	27.6	52.1	83.3	118.	164.	223.	292.	372.
9	29.2	54.8	87.6	124.	173.	234.	306.	389.
9 1/2	30.7	57.6	91.8	130.	181.	245.	319.	406.
10	32.2	60.3	96.1	136.	189.	256.	333.	423.
10 1/2	33.8	63.0	101.	142.	198.	267.	347.	440.
11	35.3	65.7	105.	148.	206.	278.	361.	457.
11 1/2	36.8	68.5	109.	155.	214.	289.	375.	474.
12	38.4	71.2	113.	161.	223.	300.	388.	491.
Heads.	1.8	5.7	10.9	13.4	22.2	38.0	57.0	82.0

WEIGHT OF 100 BOLTS WITH SQUARE HEADS AND NUTS.

Length under head to point.	DIAMETER OF BOLTS.								
	$\frac{1}{4}$ in.	$\frac{5}{16}$ in.	$\frac{3}{8}$ in.	$\frac{7}{16}$ in.	$\frac{1}{2}$ in.	$\frac{5}{8}$ in.	$\frac{3}{4}$ in.	$\frac{7}{8}$ in.	1 in.
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.
1½	4.0	7.0	10.5	15.2	22.5	39.5	63.0	....	.....
1¾	4.4	7.5	11.3	16.3	23.8	41.6	66.0	....	.....
2	4.8	8.0	12.0	17.4	25.2	43.8	69.0	109.0	163
2¼	5.2	8.5	12.8	18.5	26.5	45.8	72.0	113.3	169
2½	5.5	9.0	13.5	19.6	27.8	48.0	75.0	117.5	174
2¾	5.8	9.5	14.3	20.7	29.1	50.1	78.0	121.8	180
3	6.3	10.0	15.0	21.8	30.5	52.3	81.0	126.0	185
3½	7.0	11.0	16.5	24.0	33.1	56.5	87.0	134.3	196
4	7.8	12.0	18.0	26.2	35.8	60.8	93.1	142.5	207
4½	8.5	13.0	19.5	28.4	38.4	65.0	99.1	151.0	218
5	9.3	14.0	21.0	30.6	41.1	69.3	105.2	159.6	229
5½	10.0	15.0	22.5	32.8	43.7	73.5	111.3	168.0	240
6	10.8	16.0	24.0	35.0	46.4	77.8	117.3	176.6	251
6½	......	......	25.5	37.2	49.0	82.0	123.4	185.0	262
7	......	......	27.0	39.4	51.7	86.3	129.4	193.7	273
7½	......	......	28.5	41.6	54.3	90.5	135.0	202.0	284
8	......	......	30.0	43.8	59.6	94.8	141.5	210.7	295
9	......	......	......	46.0	64.9	103.3	153.6	227.8	317
10	......	......	......	48.2	70.2	111.8	165.7	224.8	339
11	......	......	......	50.4	75.5	120.3	177.8	261.9	360
12	......	......	......	52.6	80.8	128.8	189.9	278.9	382
13	......	......	......	......	86.1	137.3	202.0	296.0	404
14	......	......	......	......	91.4	145.8	214.1	313.0	426
15	......	......	......	......	96.7	154.3	226.2	330.1	448
16	......	......	......	......	102.0	162.8	238.3	347.1	470
17	......	......	......	......	107.3	171.0	250.4	364.2	492
18	......	......	......	......	112.6	179.5	262.6	381.2	514
19	......	......	......	......	117.9	188.0	274.7	398.3	536
20	......	......	......	......	123.2	206.5	286.8	415.3	558
Per inch additional	1.4	2.1	3.1	4.2	5.5	8.5	12.3	16.7	21.8

WEIGHTS OF NUTS AND BOLT-HEADS, IN POUNDS.

For Calculating the Weight of Longer Bolts.

Diameter of Bolt in Inches.		¼	⅜	½	⅝	¾	⅞
Weight of Hexagon Nut and Head	......	.017	.057	.128	.267	.43	.73
Weight of Square Nut and Head	......	.021	.069	.164	.320	.55	.88
Diameter of Bolt in Inches.	1	1¼	1½	1¾	2	2½	3
Weight of Hexagon Nut and Head	1.10	2.14	3.78	5.6	8.75	17	28.8
Weight of Square Nut and Head	1.31	2.56	4.42	7.0	10.5	21	36.4

SIZES AND WEIGHTS OF HOT PRESSED SQUARE NUTS.

The sizes are the usual manufacturers', not the Franklin Institute Standard. Both weights and sizes are for the unfinished Nut. The weights are calculated, one cubic foot weighing 480 lbs.

Size of Bolt.	Weight of 100 Nuts	Rough Hole.	Thickness of Nut.	Side of Square.	Diagonal.	No. of Nuts in 100 lbs.
1/4	1.5	7/32	1/4	1/2	.71	6800
5/16	2.9	9/32	5/16	5/8	.88	3480
3/8	4.9	11/32	3/8	3/4	1.06	2050
7/16	7.7	13/32	7/16	7/8	1.24	1290
1/2	8.6	7/16	1/2	7/8	1.24	1170
1/2	11.8	7/16	1/2	1	1.41	850
9/16	16.7	1/2	9/16	1 1/8	1.59	600
5/8	17.7	9/16	5/8	1 1/8	1.59	570
5/8	22.8	9/16	5/8	1 1/4	1.77	440
3/4	32.3	21/32	3/4	1 3/8	1.94	310
3/4	39.8	21/32	3/4	1 1/2	2.12	251
7/8	53.	25/32	7/8	1 5/8	2.30	190
7/8	63.	25/32	7/8	1 3/4	2.47	159
1	68.	7/8	1	1 3/4	2.47	146
1	94.	7/8	1	2	2.83	106
1 1/8	103.	15/16	1 1/8	2	2.83	97
1 1/8	137.	15/16	1 1/8	2 1/4	3.18	73
1 1/4	145.	1 1/16	1 1/4	2 1/4	3.18	69
1 1/4	186.	1 1/16	1 1/4	2 1/2	3.54	54
1 3/8	247.	1 3/16	1 3/8	2 3/4	3.89	41
1 1/2	319.	1 5/16	1 1/2	3	4.24	31.3
1 5/8	400.	1 7/16	1 5/8	3 1/4	4.60	24.8
1 3/4	500.	1 9/16	1 3/4	3 1/2	4.95	19.9
1 7/8	620.	1 11/16	1 7/8	3 3/4	5.30	16.2
2	750.	1 13/16	2	4	5.66	13.4
2 1/8	780.	1 7/8	2 1/8	4	5.66	12.8
2 1/4	930.	2	2 1/4	4 1/4	6.01	10.7
2 3/8	960.	2 1/8	2 3/8	4 1/4	6.01	10.4
2 1/2	1130.	2 1/4	2 1/2	4 1/2	6.36	8.9
2 3/4	1370.	2 7/16	2 3/4	4 3/4	6.72	7.3
3	1610.	2 11/16	3	5	7.07	6.2
3 1/4	2110.	2 15/16	3 1/4	5 1/2	7.78	4.7
3 1/2	2750.	3 1/8	3 1/2	6	8.49	3.6

SIZES AND WEIGHTS OF HOT PRESSED HEXAGON NUTS.

The sizes are the usual manufacturers', not the Franklin Institute Standard. Both weights and sizes are for the unfinished Nut. The weights are calculated, one cubic foot weighing 480 lbs.

Size of Bolt.	Weight of 100 Nuts.	Rough Hole.	Thickness of Nut.	Short Diameter.	Long Diameter.	No. of Nuts in 100 lbs.
1/4	1.3	7/32	1/4	1/2	.58	8000
5/16	2.4	9/32	5/16	5/8	.72	4170
3/8	4.1	11/32	3/8	3/4	.87	2410
7/16	6.8	13/32	7/16	7/8	1.01	1460
1/2	7.1	7/16	1/2	7/8	1.01	1410
1/2	9.8	7/16	1/2	1	1.15	1020
9/16	14.0	1/2	9/16	1 1/8	1.30	710
5/8	14.7	9/16	5/8	1 1/8	1.30	680
5/8	19.1	9/16	5/8	1 1/4	1.44	520
5/8	22.9	9/16	3/4	1 1/4	1.44	440
3/4	27.2	21/32	3/4	1 3/8	1.59	370
3/4	39.	21/32	7/8	1 1/2	1.73	256
7/8	44.	25/32	7/8	1 5/8	1.88	226
7/3	50.	25/32	1	1 5/8	1.88	198
1	57.	7/8	1	1 3/4	2.02	176
1	64.	7/8	1 1/8	1 3/4	2.02	156
1 1/8	96.	15/16	1 1/4	2	2.31	104
1 1/4	134.	1 1/16	1 3/8	2 1/4	2.60	75
1 3/8	180.	1 3/16	1 1/2	2 1/2	2.89	56
1 1/2	235.	1 5/16	1 5/8	2 3/4	3.18	42
1 5/8	300.	1 7/16	1 3/4	3	3.46	33.4
1 3/4	370.	1 9/16	1 7/8	3 1/4	3.75	26.7
1 7/8	460.	1 11/16	2	3 1/2	4.04	21.5
2	450.	1 13/16	2	3 1/2	4.04	22.4
2 1/8	560.	1 7/8	2 1/8	3 3/4	4.33	18.0
2 1/4	560.	2	2 1/4	3 3/4	4.33	17.7
2 3/8	680.	2 1/8	2 3/8	4	4.62	14.7
2 1/2	810.	2 1/4	2 1/2	4 1/4	4.91	12.3
2 3/4	980.	2 7/16	2 3/4	4 1/2	5.20	10.2
3	1150.	2 11/16	3	4 3/4	5.48	8.7
3 1/4	1340.	2 15/16	3 1/4	5	5.77	7.5
3 1/2	1580.	3 1/8	3 1/2	5 1/4	6.06	6.3

UPSET SCREW ENDS FOR ROUND AND SQUARE BARS.

Dia. of Round or Side of Square Bar. Inches.	ROUND BARS.				SQUARE BARS.			
	Dia. of Upset Screw End. Inches.	Dia. of Screw at Root of Thread. Inches.	Threads per Inch. No.	Excess of Effective Area of Screw End over Bar. Per Cent.	Dia. of Upset Screw End. Inches.	Dia. of Screw at Root of Thread. Inches.	Threads per Inch. No.	Excess of Effective Area of Screw End over Bar. Per Cent.
½	¾	.620	10	54	¾	.620	10	21
9/16	¾	.620	10	21	⅞	.731	9	33
⅝	⅞	.731	9	37	1	.837	8	41
11/16	1	.837	8	48	1	.837	8	17
¾	1	.837	8	25	1⅛	.940	7	23
13/16	1⅛	.940	7	34	1¼	1.065	7	35
⅞	1¼	1.065	7	48	1⅜	1.160	6	38
15/16	1¼	1.065	7	29	1⅜	1.160	6	20
1	1⅜	1.160	6	35	1½	1.284	6	29
1 1/16	1⅜	1.160	6	19	1⅝	1.389	5½	34
1⅛	1½	1.284	6	30	1⅝	1.389	5½	20
1 3/16	1½	1.284	6	17	1¾	1.490	5	24
1¼	1⅝	1.389	5½	23	1⅞	1.615	5	31
1 5/16	1¾	1.490	5	29	1⅞	1.615	5	19
1⅜	1¾	1.490	5	18	2	1.712	4½	22
1 7/16	1⅞	1.615	5	26	2⅛	1.837	4½	28
1½	2	1.712	4½	30	2⅛	1.837	4½	18
1 9/16	2	1.712	4½	20	2¼	1.962	4½	24
1⅝	2⅛	1.837	4½	28	2⅜	2.087	4½	30
1 11/16	2⅛	1.837	4½	18	2⅜	2.087	4½	20
1¾	2¼	1.962	4½	26	2½	2.175	4	21
1 13/16	2¼	1.962	4½	17	2⅝	2.300	4	26
1⅞	2⅜	2.087	4½	24	2⅝	2.300	4	18
1 15/16	2½	2.175	4	26	2¾	2.425	4	23
2	2½	2.175	4	18	2⅞	2.550	4	28
2 1/16	2⅝	2.300	4	24	2⅞	2.550	4	20
2⅛	2⅝	2.300	4	17	3	2.629	3½	20
2 3/16	2¾	2.425	4	23	3⅛	2.754	3½	24

UPSET SCREW ENDS.

(CONTINUED.)

Dia. of Round or Side of Square Bar. Inches.	ROUND BARS. Dia. of Upset Screw End. Inches.	ROUND BARS. Dia. of Screw at Root of Thread. Inches.	ROUND BARS. Threads per Inch. No.	ROUND BARS. Excess of Effective Area of Screw End over Bar. Per Cent.	SQUARE BARS. Dia. of Upset Screw End. Inches.	SQUARE BARS. Dia. of Screw at Root of Thread. Inches.	SQUARE BARS. Threads per Inch. No.	SQUARE BARS. Excess of Effective Area of Screw End over Bar. Per Cent.
2¼	2⅞	2.550	4	28	3⅛	2.754	3½	18
2 5/16	2⅞	2.550	4	22	3¼	2.879	3½	22
2⅜	3	2.629	3½	23	3⅜	3.004	3½	26
2 7/16	3⅛	2.754	3½	28	3⅜	3.004	3½	19
2½	3⅛	2.754	3½	21	3½	3.100	3¼	21
2 9/16	3¼	2.879	3½	26	3⅝	3.225	3¼	24
2⅝	3¼	2.879	3½	20	3⅝	3.225	3¼	19
2 11/16	3⅜	3.004	3½	25	3¾	3.317	3	20
2¾	3⅜	3.004	3½	19	3⅞	3.442	3	23
2 13/16	3½	3.100	3¼	22	3⅞	3.442	3	18
2⅞	3⅝	3.225	3¼	26	4	3.567	3	21
2 15/16	3⅝	3.225	3¼	21	4⅛	3.692	3	24
3	3¾	3.317	3	22	4⅛	3.692	3	19
3⅛	3⅞	3.442	3	21	4⅜	3.923	2⅞	24
3¼	4	3.567	3	20	4½	4.028	2¾	21
3⅜	4⅛	3.692	3	20	4⅝	4.153	2¾	19
3½	4¼	3.798	2⅞	18				
3⅝	4½	4.028	2¾	23				
3¾	4⅝	4.153	2¾	23				
3⅞	4¾	4.255	2⅝	21				

REMARKS.—As upsetting reduces the strength, bars having the same diameter at root of thread as that of the bar, invariably break in the screw end, when tested to destruction, without developing the full strength of the bar. It is therefore necessary to make up for this loss in strength by an excess of metal in the upset screw ends over that in the bar.

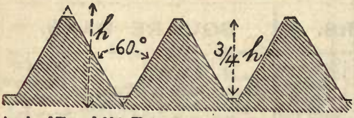
The above table is the result of numerous tests on finished bars made by The Carnegie Steel Company, Limited, and gives proportions that will cause the bar to break in the body in preference to the upset end.

The screw threads in above table are the Franklin Institute standard.

To make one upset end for 5″ length of thread allow 6″ length of rod additional.

STANDARD SCREW THREADS, NUTS AND BOLT HEADS.—Recommended by the Franklin Institute.

SCREW THREADS.



Angle of Thread 60°. Flat at Top and Bottom = ⅛ of pitch.

Dia. of Screw. Inches.	Dia. at Root of Thread. Inches.	Threads per Inch. No.
¼	.185	20
5/16	.240	18
⅜	.294	16
7/16	.344	14
½	.400	13
9/16	.454	12
⅝	.507	11
¾	.620	10
⅞	.731	9
1	.837	8
1⅛	.940	7
1¼	1.065	7
1⅜	1.160	6
1½	1.284	6
1⅝	1.389	5½
1¾	1.490	5
1⅞	1.615	5
2	1.712	4½
2¼	1.962	4½
2½	2.175	4
2¾	2.425	4
3	2.629	3½
3¼	2.879	3½
3½	3.100	3¼
3¾	3.317	3
4	3.567	3
4¼	3.798	2⅞
4½	4.028	2¾
4¾	4.255	2⅝
5	4.480	2½
5¼	4.730	2½
5½	5.053	2⅜
5¾	5.203	2⅜
6	5.423	2¼

Nuts and Bolt Heads are determined by the following rules, which apply to Square and Hexagon Nuts both:

Short diameter of rough nut
= 1½ × dia. of bolt + ⅛ in.

Short diameter of finished nut
= 1½ × dia. of bolt + 1-16 in.

Thickness of rough nut
= diameter of bolt.

Thickness of finished nut
= diameter of bolt — 1-16 in.

Short diameter of rough head
= 1½ × dia. of bolt + ⅛ in.

Short dia. of finished head
= 1½ × dia. of bolt + 1-16 in.

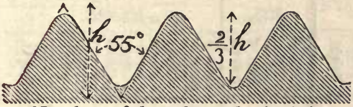
Thickness of rough head
= ½ short dia. of head.

Thickness of finished head
= dia. of bolt — 1-16 in.

The long diameter of a hexagon nut may be obtained by multiplying the short diameter by 1.155, and the long diameter of a square nut by multiplying the short diameter by 1.414.

The above standards for screw threads, nuts and bolt heads, were recommended by the Franklin Institute in Dec. 1864. The standard for screw threads has been very generally adopted in the United States, but the proportions recommended for nuts and bolt heads have not found general acceptance because of the odd sizes of bar —not usually rolled by the mills—required to make the nut.

WHITWORTH'S STANDARD ANGULAR SCREW THREADS.



Angle of thread 55°.
Depth of thread = pitch of screw.
⅙ of depth is rounded off at top and bottom.

Number of threads to the inch in square threads = ½ the number in angular threads.

Dia. of Screw. In.	Threads to the inch. No.	Dia. of Screw. In.	Threads to the inch. No.	Dia. of Screw. In.	Threads to the inch. No.	Dia. of Screw. In.	Threads to the inch. No.
¼	20	1	8	2	4½	4	3
$\frac{5}{16}$	18	1⅛	7	2¼	4	4¼	2⅞
⅜	16	1¼	7	2½	4	4½	2⅞
$\frac{7}{16}$	14	1⅜	6	2¾	3½	4¾	2¾
½	12	1½	6	3	3½	5	2¾
⅝	11	1⅝	5	3¼	3¼	5¼	2⅝
¾	10	1¾	5	3½	3¼	5½	2⅝
⅞	9	1⅞	4½	3¾	3	5¾	2½
						6	2½

STANDARD SLEEVE NUTS.

SCREW.		Space between ends of rods.	SLEEVE NUT.				SCREW.		Space between ends of rods.	SLEEVE NUT.			
Diameter.	Length.		Short Diameter.	Rough Hole.	Finished Length.	Weight.	Diameter.	Length.		Short Diameter.	Rough Hole.	Finished Length.	Weight.
1	4	2½	1½	⅞	6	4.2	2¼	5	2½	3¼	$1\frac{31}{32}$	8	14.8
1⅛	4	2½	1⅝	$\frac{15}{16}$	6	4.6	2⅜	5	3	3⅜	$2\frac{3}{32}$	9	19.8
1¼	4	2½	1¾	$1\frac{1}{16}$	6	4.8	2½	5	3	3⅝	$2\frac{5}{32}$	9	20.0
1⅜	4	3	1⅞	$1\frac{5}{32}$	7	6.0	2⅝	5	2½	3¾	$2\frac{5}{16}$	9	22.7
1½	4	3	2⅛	$1\frac{9}{32}$	7	6.6	2¾	5	2½	3⅞	$2\frac{7}{16}$	9	25.2
1⅝	4	2½	2¼	1⅜	7	7.5	2⅞	6	3	4⅛	$2\frac{9}{16}$	10	29.8
1¾	4	2½	2½	1½	7	9.0	3	6	3	4¼	2⅝	10	30.5
1⅞	5	3	2⅝	1⅝	8	10.5	3⅛	6	2½	4⅜	2¾	10	34.8
2	5	3	2¾	$1\frac{23}{32}$	8	11.4	3¼	6	2½	4⅝	2⅞	10	39.2
2⅛	5	2½	3	$1\frac{27}{32}$	8	13.5	3⅜	6	3	4¾	3	11	41.0
							3½	6	3	5	3⅛	11	35.6

All dimensions are in inches. Weights are for finished nuts.

STANDARD PIN-NUTS.

PINS.		PIN-NUTS.					PINS.		PIN-NUTS.				
Diam. of Pin.	Diam. of Screw.	Threads per inch.	Short Diameter.	Long Diameter.	Thick-ness.	Weight.	Diam. of Pin.	Diam. of Screw.	Threads per inch.	Short Diameter.	Long Diameter.	Thick-ness.	Weight.
1⅞	1¼	8	2¼	2⅝	⅞	0.85	3⅞	3¼	6	5	5¾	1¼	4.74
2⅛	1½	8	2½	2⅞	31/32	1.03	4⅛	3½	6	5½	6⅜	1¼	6.19
2¼	1⅝	8	2½	2⅞	1	0.97	4⅜	3½	6	5½	6⅜	1¼	6.19
2⅜	1¾	8	3	3½	1	1.50	4⅝	3¾	6	5½	6⅜	1¼	5.37
2½	1⅞	8	3	3½	1	1.37	4⅞	4	6	6	6 15/16	1¼	6.63
2⅝	2	8	3½	4	1	2.06	5⅛	4	6	6	6 15/16	1¼	6.63
2¾	2⅛	8	3½	4	1	1.96	5⅜	4¼	6	6	6 15/16	1¼	5.82
2⅞	2¼	8	4	4⅝	1¼	3.38	5⅝	4½	6	6¾	7 13/16	1¼	8.53
3	2⅜	8	4	4⅝	1¼	3.22	5⅞	4¾	6	6¾	7 13/16	1¼	7.59
3⅛	2½	8	4¼	4⅞	1¼	3.63	6⅛	4¾	6	6¾	7 13/16	1¼	7.59
3¼	2⅝	8	4¼	4⅞	1¼	3.41	6⅜	5	6	8	9¼	1¼	13.06
3⅜	2¾	6	4½	5 3/16	1¼	4.09	6⅝	5¼	6	8	9¼	1½	14.86
3½	2⅞	6	4¾	5½	1¼	4.63	6⅞	5½	6	8	9¼	1½	14.00
3⅝	3	6	5	5¾	1¼	5.25	7⅛	5¾	6	8	9¼	1½	13.10

All dimensions given above are in inches. Weights refer to untapped nuts.

WOOD SCREWS.

Diameter = number × 0.01325 + 0.056.

No.	Diam.	No.	Diam.	No.	Diam.	No.	Diam.	No.	Diam.
0	.056	6	.135	12	.215	18	.293	24	.374
1	.069	7	.149	13	.228	19	.308	25	.387
2	.082	8	.162	14	.241	20	.321	26	.401
3	.096	9	.175	15	.255	21	.334	27	.414
4	.109	10	.188	16	.268	22	.347	28	.427
5	.122	11	.201	17	.281	23	.361	29	.440
								30	.453

SPIKES, NAILS AND TACKS.

STANDARD STEEL WIRE NAILS.						STEEL WIRE SPIKES.			COMMON IRON NAILS.		
		Common.		Finishing.							
Sizes.	Length.	Diam. inches.	No. per pound.	Diam. inches.	No. per pound.	Length.	Diam. inches.	No. per pound.	Size.	Length.	No. per lb.
2d	1″	.0524	1060	.0453	1558	3″	.1620	41	2d	1″	800
3d	1¼″	.0588	640	.0508	913	3½″	.1819	30	3d	1¼″	400
4d	1½″	.0720	380	.0508	761	4″	.2043	23	4d	1½″	300
5d	1¾″	.0764	275	.0571	500	4½″	.2294	17	5d	1¾″	200
6d	2″	.0808	210	.0641	350	5″	.2576	13	6d	2″	150
7d	2¼″	.0858	160	.0641	315	5½″	.2893	11	7d	2¼″	120
8d	2½″	.0935	115	.0720	214	6″	.2893	10	8d	2½″	85
9d	2¾″	.0963	93	.0720	195	6½″	.2249	7½	9d	2¾″	75
10d	3″	.1082	77	.0808	137	7″	.2249	7	10d	3″	60
12d	3¼″	.1144	60	.0808	127	8″	.3648	5	12d	3¼″	50
16d	3½″	.1285	48	.0907	90	9″	.3648	4½	16d	3½″	40
20d	4″	.1620	31	.1019	62	. .	. .	. .	20d	4″	20
30d	4½″	.1819	22	. .	. .	. .	. .	. .	30d	4½″	16
40d	5″	.2043	17	. .	. .	. .	. .	. .	40d	5″	14
50d	5½″	.2294	13	. .	. .	. .	. .	. .	50d	5½″	11
60d	6″	.2576	11	. .	. .	. .	. .	. .	60d	6″	8

TACKS.

Title. oz.	Length. in.	Number per pound.	Title. oz.	Length. in.	Number per pound.	Title. oz.	Length. in.	Number per pound.
1	⅛	16000	4	$\frac{7}{16}$	4000	14	$\frac{13}{16}$	1143
1½	$\frac{3}{16}$	10666	6	$\frac{9}{16}$	2666	16	⅞	1000
2	¼	8000	8	⅝	2000	18	$\frac{15}{16}$	888
2½	$\frac{5}{16}$	6400	10	$\frac{11}{16}$	1600	20	1	800
3	⅜	5333	12	¾	1333	22	$1\frac{1}{16}$	727
						24	1⅛	666

WROUGHT SPIKES.

Number to a keg of 150 lbs.

Length. In.	1-4 inch. No.	5-16 inch. No.	3-8 inch. No.	Length. In.	1-4 inch. No.	5-16 inch, No.	3-8 inch. No.	7-16 inch. No.	1-2 inch No.
3	2250	. .	. .	7	1161	662	482	445	306
3½	1890	1208	. .	8	. .	635	455	384	256
4	1650	1135	. .	9	. .	573	424	300	240
4½	1464	1064	. .	10	. .	. .	391	270	222
5	1380	930	742	11	. .	. .	. .	249	203
6	1292	868	570	12	. .	. .	. .	236	180

WEIGHT OF SHEETS OF WROUGHT IRON, STEEL, COPPER AND BRASS. (From Haswell.)

Weights per Square Foot. Thickness by Birmingham Gauge.

No. of Gauge.	Thickness in inches.	Iron.	Steel.	Copper.	Brass.
0000	.454	18.22	18.46	20.57	19.43
000	.425	17.05	17.28	19.25	18.19
00	.38	15.25	15.45	17.21	16.26
0	.34	13.64	13.82	15.40	14.55
1	.3	12.04	12.20	13.59	12.84
2	.284	11.40	11.55	12.87	12.16
3	.259	10.39	10.53	11.73	11.09
4	.238	9.55	9.68	10.78	10.19
5	.22	8.83	8.95	9.97	9.42
6	.203	8.15	8.25	9.20	8.69
7	.18	7.22	7.32	8.15	7.70
8	.165	6.62	6.71	7.47	7.06
9	.148	5.94	6.02	6.70	6.33
10	.134	5.38	5.45	6.07	5.74
11	.12	4.82	4.88	5.44	5.14
12	.109	4.37	4.43	4.94	4.67
13	.095	3.81	3.86	4.30	4.07
14	.083	3.33	3.37	3.76	3.55
15	.072	2.89	2.93	3.26	3.08
16	.065	2.61	2.64	2.94	2.78
17	.058	2.33	2.36	2.63	2.48
18	.049	1.97	1.99	2.22	2.10
19	.042	1.69	1.71	1.90	1.80
20	.035	1.40	1.42	1.59	1.50
21	.032	1.28	1.30	1.45	1.37
22	.028	1.12	1.14	1.27	1.20
23	.025	1.00	1.02	1.13	1.07
24	.022	.883	.895	1.00	.942
25	.02	.803	.813	.906	.856
26	.018	.722	.732	.815	.770
27	.016	.642	.651	.725	.685
28	.014	.562	.569	.634	.599
29	.013	.522	.529	.589	.556
30	.012	.482	.488	.544	.514
31	.01	.401	.407	.453	.428
32	.009	.361	.366	.408	.385
33	.008	.321	.325	.362	.342
34	.007	.281	.285	.317	.300
35	.005	.201	.203	.227	.214
Specific Gravity,		7.704	7.806	8.698	8.218
Weight Cubic Foot,		481.25	487.75	543.6	513.6
" " Inch,		.2787	.2823	.3146	.2972

WEIGHT OF SHEETS OF WROUGHT IRON, STEEL, COPPER AND BRASS. (From Haswell.)

Weights per Sq. Foot. Thickness by American (Browne & Sharpe's) Gauge.

No. of Gauge.	Thickness in inches.	Iron.	Steel.	Copper.	Brass.
0000	.46	18.46	18.70	20.84	19.69
000	.4096	16.44	16.66	18.56	17.53
00	.3648	14.64	14.83	16.53	15.61
0	.3249	13.04	13.21	14.72	13.90
1	.2893	11.61	11.76	13.11	12.38
2	.2576	10.34	10.48	11.67	11.03
3	.2294	9.21	9.33	10.39	9.82
4	.2043	8.20	8.31	9.26	8.74
5	.1819	7.30	7.40	8.24	7.79
6	.1620	6.50	6.59	7.34	6.93
7	.1443	5.79	5.87	6.54	6.18
8	.1285	5.16	5.22	5.82	5.50
9	.1144	4.59	4.65	5.18	4.90
10	.1019	4.09	4.14	4.62	4.36
11	.0907	3.64	3.69	4.11	3.88
12	.0808	3.24	3.29	3.66	3.46
13	.0720	2.89	2.93	3.26	3.08
14	.0641	2.57	2.61	2.90	2.74
15	.0571	2.29	2.32	2.59	2.44
16	.0508	2.04	2.07	2.30	2.18
17	.0453	1.82	1.84	2.05	1.94
18	.0403	1.62	1.64	1.83	1.73
19	.0359	1.44	1.46	1.63	1.54
20	.0320	1.28	1.30	1.45	1.37
21	.0285	1.14	1.16	1.29	1.22
22	.0253	1.02	1.03	1.15	1.08
23	.0226	.906	.918	1.02	.966
24	.0201	.807	.817	.911	.860
25	.0179	.718	.728	.811	.766
26	.0159	.640	.648	.722	.682
27	.0142	.570	.577	.643	.608
28	.0126	.507	.514	.573	.541
29	.0113	.452	.458	.510	.482
30	.0100	.402	.408	.454	.429
31	.0089	.358	.363	.404	.382
32	.0080	.319	.323	.360	.340
33	.0071	.284	.288	.321	.303
34	.0063	.253	.256	.286	.270
35	.0056	.225	.228	.254	.240

As there are many gauges in use differing from each other, and even the thicknesses of a certain specified gauge, as the Birmingham, are not assumed the same by all manufacturers, orders for sheets and wire should always state the weight per square foot, or the thickness in thousandths of an inch.

WROUGHT IRON WELDED STEAM, GAS AND WATER PIPE.

Table of Standard Dimensions, as manufactured by National Tube Works Company.

DIAMETER.			Thick-ness.	CIRCUMFERENCE.		TRANSVERSE AREAS.			Length of Pipe per sq. ft. of		Length of Pipe containing one cubic foot.	Nominal Weight per foot.	Number of Threads per inch of Screw.
Nominal Internal.	Actual External.	Actual Internal.		External.	Internal.	External.	Internal.	Metal.	External Surface.	Internal Surface.			
inches.	inches.	inches.	inches.	inches.	inches.	sq. ins.	sq. ins.	sq. ins.	feet.	feet.	feet.	pounds.	
1/8	.405	.27	.068	1.272	.848	.129	.0573	.0717	9.44	14.15	2513.	.241	27
1/4	.54	.364	.088	1.696	1.144	.229	.1041	.1249	7.075	10.49	1383.3	.42	18
3/8	.675	.494	.091	2.121	1.552	.358	.1917	.1663	5.657	7.73	751.2	.559	18
1/2	.84	.623	.109	2.639	1.957	.554	.3048	.2492	4.547	6.13	472.4	.837	14
3/4	1.05	.824	.113	3.299	2.589	.866	.5333	.3327	3.637	4.635	270.	1.115	14
1	1.315	1.048	.134	4.131	3.292	1.358	.8626	.4954	2.904	3.645	166.9	1.668	11 1/2
1 1/4	1.66	1.38	.14	5.215	4.335	2.164	1.496	.668	2.301	2.768	96.25	2.244	11 1/2
1 1/2	1.9	1.611	.145	5.969	5.061	2.835	2.038	.797	2.01	2.371	70.66	2.678	11 1/2
2	2.375	2.067	.154	7.461	6.494	4.43	3.356	1.074	1.608	1.848	42.91	3.609	11 1/2
2 1/2	2.875	2.468	.204	9.032	7.753	6.492	4.784	1.708	1.328	1.547	30.1	5.739	8
3	3.5	3.067	.217	10.996	9.636	9.621	7.388	2.243	1.091	1.245	19.5	7.536	8
3 1/2	4.	3.548	.226	12.566	11.146	12.566	9.887	2.679	.955	1.077	14.57	9.001	8
4	4.5	4.026	.237	14.137	12.648	15.904	12.73	3.174	.849	.949	11.31	10.665	8
4 1/2	5.	4.508	.246	15.708	14.162	19.635	15.961	3.674	.764	.848	9.02	12.34	8
5	5.563	5.045	.259	17.477	15.849	24.306	19.99	4.316	.687	.757	7.2	14.502	8
6	6.625	6.065	.28	20.813	19.054	34.472	28.888	5.584	.577	.63	4.98	18.762	8
7	7.625	7.023	.301	23.955	22.063	45.664	38.738	6.926	.501	.544	3.72	23.271	8
8	8.625	7.982	.322	27.096	25.076	58.426	50.04	8.386	.443	.478	2.88	28.177	8
9	9.625	8.937	.344	30.238	28.076	72.76	62.73	10.03	.397	.427	2.29	33.701	8
10	10.75	10.019	.366	33.772	31.477	90.763	78.839	11.924	.355	.382	1.82	40.065	8

WEIGHT OF A CUBIC FOOT OF SUBSTANCES.

NAMES OF SUBSTANCES.	Average Weight. Lbs.
Aluminum,	162
Anthracite, solid, of Pennsylvania,	93
" broken, loose,	54
" " moderately shaken,	58
" heaped bushel, loose,	(80)
Ash, American white, dry,	38
Asphaltum,	87
Brass, (Copper and Zinc,) cast,	504
" rolled,	524
Brick, best pressed,	150
" common hard,	125
" soft, inferior,	100
Brickwork, pressed brick,	140
" ordinary,	112
Cement, hydraulic, ground, loose, American, Rosendale,	56
" " " " " Louisville,	50
" " " " English, Portland,	90
Cherry, dry,	42
Chestnut, dry,	41
Clay, potters', dry,	119
" in lump, loose,	63
Coal, bituminous, solid,	84
" " broken, loose,	49
" " heaped bushel, loose,	(74)
Coke, loose, of good coal,	62
" " heaped bushel,	(40)
Copper, cast,	542
" rolled,	548
Earth, common loam, dry, loose,	76
" " " " moderately rammed,	95
" as a soft flowing mud,	108
Ebony, dry,	76
Elm, dry,	35
Flint,	162

WEIGHT OF SUBSTANCES—Continued.

Names of Substances.	Average Weight Lbs.
Glass, common window,	157
Gneiss, common,	168
Gold, cast, pure, or 24 carat,	1204
" pure, hammered,	1217
Granite,	170
Gravel, about the same as sand, which see.	
Gypsum (plaster of paris),	142
Hemlock, dry,	25
Hickory, dry,	53
Hornblende, black,	203
Ice,	58.7
Iron, cast,	450
" wrought, purest,	485
" " average,	480
Ivory,	114
Lead,	711
Lignum Vitæ, dry,	83
Lime, quick, ground, loose, or in small lumps,	53
" " " " thoroughly shaken,	75
" " " " per struck bushel,	(66)
Limestones and Marbles,	168
" " loose, in irregular fragments,	96
Magnesium,	109
Mahogany, Spanish, dry,	53
" Honduras, dry,	35
Maple, dry,	49
Marbles, see Limestones.	
Masonry, of granite or limestone, well dressed,	165
" " mortar rubble,	154
" " dry " (well scabbled,)	138
" " sandstone, well dressed,	144
Mercury, at 32° Fahrenheit,	849
Mica,	183
Mortar, hardened,	103
Mud, dry, close,	80 to 110

WEIGHT OF SUBSTANCES—Continued.

NAMES OF SUBSTANCES.	Average Weight. Lbs.
Mud, wet, fluid, maximum,	120
Oak, live, dry,	59
" white, dry,	50
" other kinds,	32 to 45
Petroleum,	55
Pine, white, dry,	25
" yellow, Northern,	34
" " Southern,	45
Platinum,	1342
Quartz, common, pure,	165
Rosin,	69
Salt, coarse, Syracuse, N. Y.,	45
" Liverpool, fine, for table use,	49
Sand, of pure quartz, dry, loose,	90 to 106
" well shaken,	99 to 117
" perfectly wet,	120 to 140
Sandstones, fit for building,	151
Shales, red or black,	162
Silver,	655
Slate,	175
Snow, freshly fallen,	5 to 12
" moistened and compacted by rain,	15 to 50
Spruce, dry,	25
Steel,	490
Sulphur,	125
Sycamore, dry,	37
Tar,	62
Tin, cast,	459
Turf or Peat, dry, unpressed,	20 to 30
Walnut, black, dry,	38
Water, pure rain or distilled, at 60° Fahrenheit,	62⅓
" sea,	64
Wax, bees,	60.5
Zinc or Spelter,	437.5

Green timbers usually weigh from one-fifth to one-half more than dry.

AREAS and CIRCUMFERENCES OF CIRCLES.

For Diameters from $\frac{1}{10}$ to 100, advancing by Tenths.

Diam.	Area.	Circum.	Diam.	Area.	Circum.
0.0			4.0	12.5664	12.5664
.1	.007854	.31416	.1	13.2025	12.8805
.2	.031416	.62832	.2	13.8544	13.1947
.3	.070686	.94248	.3	14.5220	13.5088
.4	.12566	1.2566	.4	15.2053	13.8230
.5	.19635	1.5708	.5	15.9043	14.1372
.6	.28274	1.8850	.6	16.6190	14.4513
.7	.38485	2.1991	.7	17.3494	14.7655
.8	.50266	2.5133	.8	18.0956	15.0796
.9	.63617	2.8274	.9	18.8574	15.3938
1.0	.7854	3.1416	5.0	19.6350	15.7080
.1	.9503	3.4558	.1	20.4282	16.0221
.2	1.1310	3.7699	.2	21.2372	16.3363
.3	1.3273	4.0841	.3	22.0618	16.6504
.4	1.5394	4.3982	.4	22.9022	16.9646
.5	1.7671	4.7124	.5	23.7583	17.2788
.6	2.0106	5.0265	.6	24.6301	17.5929
.7	2.2698	5.3407	.7	25.5176	17.9071
.8	2.5447	5.6549	.8	26.4208	18.2212
.9	2.8353	5.9690	.9	27.3397	18.5354
2.0	3.1416	6.2832	6.0	28.2743	18.8496
.1	3.4636	6.5973	.1	29.2247	19.1637
.2	3.8013	6.9115	.2	30.1907	19.4779
.3	4.1548	7.2257	.3	31.1725	19.7920
.4	4.5239	7.5398	.4	32.1699	20.1062
.5	4.9087	7.8540	.5	33.1831	20.4204
.6	5.3093	8.1681	.6	34.2119	20.7345
.7	5.7256	8.4823	.7	35.2565	21.0487
.8	6.1575	8.7965	.8	36.3168	21.3628
.9	6.6052	9.1106	.9	37.3928	21.6770
3.0	7.0686	9.4248	7.0	38.4845	21.9911
.1	7.5477	9.7389	.1	39.5919	22.3053
.2	8.0425	10.0531	.2	40.7150	22.6195
.3	8.5530	10.3673	.3	41.8539	22.9336
.4	9.0792	10.6814	.4	43.0084	23.2478
.5	9.6211	10.9956	.5	44.1786	23.5619
.6	10.1788	11.3097	.6	45.3646	23.8761
.7	10.7521	11.6239	.7	46.5663	24.1903
.8	11.3411	11.9381	.8	47.7836	24.5044
.9	11.9459	12.2522	.9	49.0167	24.8186

AREAS and CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Area.	Circum.	Diam.	Area.	Circum.
8.0	50.2655	25.1327	12.0	113.0973	37.6991
.1	51.5300	25.4469	.1	114.9901	38.0133
.2	52.8102	25.7611	.2	116.8987	38.3274
.3	54.1061	26.0752	.3	118.8229	38.6416
.4	55.4177	26.3894	.4	120.7628	38.9557
.5	56.7450	26.7035	.5	122.7185	39.2699
.6	58.0880	27.0177	.6	124.6898	39.5841
.7	59.4468	27.3319	.7	126.6769	39.8982
.8	60.8212	27.6460	.8	128.6796	40.2124
.9	62.2114	27.9602	.9	130.6981	40.5265
9.0	63.6173	28.2743	13.0	132.7323	40.8407
.1	65.0388	28.5885	.1	134.7822	41.1549
.2	66.4761	28.9027	.2	136.8478	41.4690
.3	67.9291	29.2168	.3	138.9291	41.7832
.4	69.3978	29.5310	.4	141.0261	42.0973
.5	70.8822	29.8451	.5	143.1388	42.4115
.6	72.3823	30.1593	.6	145.2672	42.7257
.7	73.8981	30.4734	.7	147.4114	43.0398
.8	75.4296	30.7876	.8	149.5712	43.3540
.9	76.9769	31.1018	.9	151.7468	43.6681
10.0	78.5398	31.4159	14.0	153.9380	43.9823
.1	80.1185	31.7301	.1	156.1450	44.2965
.2	81.7128	32.0442	.2	158.3677	44.6106
.3	83.3229	32.3584	.3	160.6061	44.9248
.4	84.9487	32.6726	.4	162.8602	45.2389
.5	86.5901	32.9867	.5	165.1300	45.5531
.6	88.2473	33.3009	.6	167.4155	45.8673
.7	89.9202	33.6150	.7	169.7167	46.1814
.8	91.6088	33.9292	.8	172.0336	46.4956
.9	93.3132	34.2434	.9	174.3662	46.8097
11.0	95.0332	34.5575	15.0	176.7146	47.1239
.1	96.7689	34.8717	.1	179.0786	47.4380
.2	98.5203	35.1858	.2	181.4584	47.7522
.3	100.2875	35.5000	.3	183.8539	48.0664
.4	102.0703	35.8142	.4	186.2650	48.3805
.5	103.8689	36.1283	.5	188.6919	48.6947
.6	105.6832	36.4425	.6	191.1345	49.0088
.7	107.5132	36.7566	.7	193.5928	49.3230
.8	109.3588	37.0708	.8	196.0668	49.6372
.9	111.2202	37.3850	.9	198.5565	49.9513

AREAS and CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Area.	Circum.	Diam.	Area.	Circum.
16.0	201.0619	50.2655	20.0	314.1593	62.8319
.1	203.5831	50.5796	.1	317.3087	63.1460
.2	206.1199	50.8938	.2	320.4739	63.4602
.3	208.6724	51.2080	.3	323.6547	63.7743
.4	211.2407	51.5221	.4	326.8513	64.0885
.5	213.8246	51.8363	.5	330.0636	64.4026
.6	216.4243	52.1504	.6	333.2916	64.7168
.7	219.0397	52.4646	.7	336.5353	65.0310
.8	221.6708	52.7788	.8	339.7947	65.3451
.9	224.3176	53.0929	.9	343.0698	65.6593
17.0	226.9801	53.4071	21.0	346.3606	65.9734
.1	229.6583	53.7212	.1	349.6671	66.2876
.2	232.3522	54.0354	.2	352.9894	66.6018
.3	235.0618	54.3496	.3	356.3273	66.9159
.4	237.7871	54.6637	.4	359.6809	67.2301
.5	240.5282	54.9779	.5	363.0503	67.5442
.6	243.2849	55.2920	.6	366.4354	67.8584
.7	246.0574	55.6062	.7	369.8361	68.1726
.8	248.8456	55.9203	.8	373.2526	68.4867
.9	251.6494	56.2345	.9	376.6848	68.8009
18.0	254.4690	56.5486	22.0	380.1327	69.1150
.1	257.3043	56.8628	.1	383.5963	69.4292
.2	260.1553	57.1770	.2	387.0756	69.7434
.3	263.0220	57.4911	.3	390.5707	70.0575
.4	265.9044	57.8053	.4	394.0814	70.3717
.5	268.8025	58.1195	.5	397.6078	70.6858
.6	271.7164	58.4336	.6	401.1500	71.0000
.7	274.6459	58.7478	.7	404.7078	71.3142
.8	277.5911	59.0619	.8	408.2814	71.6283
.9	280.5521	59.3761	.9	411.8707	71.9425
19.0	283.5287	59.6903	23.0	415.4756	72.2566
.1	286.5211	60.0044	.1	419.0963	72.5708
.2	289.5292	60.3186	.2	422.7327	72.8849
.3	292.5530	60.6327	.3	426.3848	73.1991
.4	295.5925	60.9469	.4	430.0526	73.5133
.5	298.6477	61.2611	.5	433.7361	73.8274
.6	301.7186	61.5752	.6	437.4354	74.1416
.7	304.8052	61.8894	.7	441.1503	74.4557
.8	307.9075	62.2035	.8	444.8809	74.7699
.9	311.0255	62.5177	.9	448.[illegible]273	75.0841

AREAS and CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Area.	Circum.	Diam.	Area.	Circum.
24.0	452.3893	75.3982	28.0	615.7522	87.9646
.1	456.1671	75.7124	.1	620.1582	88.2788
.2	459.9606	76.0265	.2	624.5800	88.5929
.3	463.7698	76.3407	.3	629.0175	88.9071
.4	467.5947	76.6549	.4	633.4707	89.2212
.5	471.4352	76.9690	.5	637.9397	89.5354
.6	475.2916	77.2832	.6	642.4243	89.8495
.7	479.1636	77.5973	.7	646.9246	90.1637
.8	483.0513	77.9115	.8	651.4407	90.4779
.9	486.9547	78.2257	9	655.9724	90.7920
25.0	490.8739	78.5398	29.0	660.5199	91.1062
.1	494.8087	78.8540	.1	665.0830	91.4203
.2	498.7592	79.1681	.2	669.6619	91.7345
.3	502.7255	79.4823	.3	674.2565	92.0487
.4	506.7075	79.7965	.4	678.8668	92.3628
.5	510.7052	80.1106	.5	683.4928	92.6770
.6	514.7185	80.4248	.6	688.1345	92.9911
.7	518.7476	80.7389	.7	692.7919	93.3053
.8	522.7924	81.0531	.8	697.4650	93.6195
.9	526.8529	81.3672	.9	702.1538	93.9336
26.0	530.9292	81.6814	30.0	706.8583	94.2478
.1	535.0211	81.9956	.1	711.5786	94.5619
.2	539.1287	82.3097	.2	716.3145	94.8761
.3	543.2521	82.6239	.3	721.0662	95.1903
4	547.3911	82.9380	.4	725.8336	95.5044
.5	551.5459	83.2522	.5	730.6167	95.8186
.6	555.7163	83.5664	.6	735.4154	96.1327
.7	559.9025	83.8805	.7	740.2299	96.4469
.8	564.1044	84.1947	.8	745.0601	96.7611
.9	568.3220	84.5088	.9	749.9060	97.0752
27.0	572.5553	84.8230	31.0	754.7676	97.3894
.1	576.8043	85.1372	.1	759.6450	97.7035
.2	581.0690	85.4513	.2	764.5380	98.0177
.3	585.3494	85.7655	.3	769.4467	98.3319
.4	589.6455	86.0796	.4	774.3712	98.6460
.5	593.9574	86.3938	.5	779.3113	98.9602
.6	598.2849	86.7080	.6	784.2672	99.2743
.7	602.6282	87.0221	.7	789.2388	99.5885
.8	606.9871	87.3363	.8	794.2260	99.9026
.9	611.3618	87.6504	.9	799.2290	100.2168

AREAS and CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Area.	Circum.	Diam.	Area.	Circum.
32.0	804.2477	100.5310	36.0	1017.8760	113.0973
.1	809.2821	100.8451	.1	1023.5387	113.4115
.2	814.3322	101.1593	.2	1029.2172	113.7257
.3	819.3980	101.4734	.3	1034.9113	114.0398
.4	824.4796	101.7876	.4	1040.6212	114.3540
.5	829.5768	102.1018	.5	1046.3467	114.6681
.6	834.6898	102.4159	.6	1052.0880	114.9823
.7	839.8185	102.7301	.7	1057.8449	115.2965
.8	844.9628	103.0442	.8	1063.6176	115.6106
.9	850.1229	103.3584	.9	1069.4060	115.9248
33.0	855.2986	103.6726	37.0	1075.2101	116.2389
.1	860.4902	103.9867	.1	1081.0299	116.5531
.2	865.6973	104.3009	.2	1086.8654	116.8672
.3	870.9202	104.6150	.3	1092.7166	117.1814
.4	876.1588	104.9292	.4	1098.5835	117.4956
.5	881.4131	105.2434	.5	1104.4662	117.8097
.6	886.6831	105.5575	.6	1110.3645	118.1239
.7	891.9688	105.8717	.7	1116.2786	118.4380
.8	897.2703	106.1858	.8	1122.2083	118.7522
.9	902.5874	106.5000	.9	1128.1538	119.0664
34.0	907.9203	106.8142	38.0	1134.1149	119.3805
.1	913.2688	107.1283	.1	1140.0918	119.6947
.2	918.6331	107.4425	.2	1146.0844	120.0088
.3	924.0131	107.7566	.3	1152.0927	120.3230
.4	929.4088	108.0708	.4	1158.1167	120.6372
.5	934.8202	108.3849	.5	1164.1564	120.9513
.6	940.2473	108.6991	.6	1170.2118	121.2655
.7	945.6901	109.0133	.7	1176.2830	121.5796
.8	951.1486	109.3274	.8	1182.3698	121.8938
.9	956.6228	109.6416	.9	1188.4724	122.2080
35.0	962.1128	109.9557	39.0	1194.5906	122.5221
.1	967.6184	110.2699	.1	1200.7246	122.8363
.2	973.1397	110.5841	.2	1206.8742	123.1504
.3	978.6768	110.8982	.3	1213.0396	123.4646
.4	984.2296	111.2124	.4	1219.2207	123.7788
.5	989.7980	111.5265	.5	1225.4175	124.0929
.6	995.3822	111.8407	.6	1231.6300	124.4071
.7	1000.9821	112.1549	.7	1237.8582	124.7212
.8	1006.5977	112.4690	.8	1244.1021	125.0354
.9	1012.2290	112.7832	.9	1250.3617	125.3495

AREAS and CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Area.	Circum.	Diam.	Area.	Circum.
40.0	1256.6371	125.6637	44.0	1520.5308	138.2301
.1	1262.9281	125.9779	.1	1527.4502	138.5442
.2	1269.2348	126.2920	.2	1534.3853	138.8584
.3	1275.5573	126.6062	.3	1541.3360	139.1726
.4	1281.8955	126.9203	.4	1548.3025	139.4867
.5	1288.2493	127.2345	.5	1555.2847	139.8009
.6	1294.6189	127.5487	.6	1562.2826	140.1153
.7	1301.0042	127.8628	.7	1569.2962	140.4292
.8	1307.4052	128.1770	.8	1576.3255	140.7434
.9	1313.8219	128.4911	.9	1583.3706	141.0575
41.0	1320.2543	128.8053	45.0	1590.4313	141.3717
.1	1326.7024	129.1195	.1	1597.5077	141.6858
.2	1333.1663	129.4336	.2	1604.5999	142.0000
.3	1339.6458	129.7478	.3	1611.7077	142.3142
.4	1346.1410	130.0619	.4	1618.8313	142.6283
.5	1352.6520	130.3761	.5	1625.9705	142.9425
.6	1359.1786	130.6903	.6	1633.1255	143.2566
.7	1365.7210	131.0044	.7	1640.2962	143.5708
.8	1372.2791	131.3186	.8	1647.4826	143.8849
.9	1378.8529	131.6327	.9	1654.6847	144.1991
42.0	1385.4424	131.9469	46.0	1661.9025	144.5133
.1	1392.0476	132.2611	.1	1669.1360	144.8274
.2	1398.6685	132.5752	.2	1676.3853	145.1416
.3	1405.3051	132.8894	.3	1683.6502	145.4557
.4	1411.9574	133.2035	.4	1690.9308	145.7699
.5	1418.6254	133.5177	.5	1698.2272	146.0841
.6	1425.3092	133.8318	.6	1705.5392	146.3982
.7	1432.0086	134.1460	.7	1712.8670	146.7124
.8	1438.7238	134.4602	.8	1720.2105	147.0265
.9	1445.4546	134.7743	.9	1727.5697	147.3407
43.0	1452.2012	135.0885	47.0	1734.9445	147.6550
.1	1458.9635	135.4026	.1	1742.3351	147.9690
.2	1465.7415	135.7168	.2	1749.7414	148.2832
.3	1472.5352	136.0310	.3	1757.1635	148.5973
.4	1479.3446	136.3451	.4	1764.6012	148.9115
.5	1486.1697	136.6593	.5	1772.0546	149.2257
.6	1493.0105	136.9734	.6	1779.5237	149.5398
.7	1499.8670	137.2876	.7	1787.0086	149.8540
.8	1506.7393	137.6018	.8	1794.5091	150.1681
.9	1513.6272	137.9159	.9	1802.0254	150.4823

AREAS and CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Area.	Circum.	Diam.	Area.	Circum.
48.0	1809.5574	150.7964	52.0	2123.7166	163.3628
.1	1817.1050	151.1106	.1	2131.8926	163.6770
.2	1824.6684	151.4248	.2	2140.0843	163.9911
.3	1832.2475	151.7389	.3	2148.2917	164.3053
.4	1839.8423	152.0531	.4	2156.5149	164.6195
.5	1847.4528	152.3672	.5	2164.7537	164.9336
.6	1855.0790	152.6814	.6	2173.0082	165.2479
.7	1862.7210	152.9956	.7	2181.2785	165.5619
.8	1870.3786	153.3097	.8	2189.5644	165.8761
.9	1878.0519	153.6239	.9	2197.8661	166.1903
49.0	1885.7409	153.9380	53.0	2206.1834	166.5044
.1	1893.4457	154.2522	.1	2214.5165	166.8186
.2	1901.1662	154.5664	.2	2222.8653	167.1327
.3	1908.9024	154.8805	.3	2231.2298	167.4469
.4	1916.6543	155.1947	.4	2239.6100	167.7610
.5	1924.4218	155.5088	.5	2248.0059	168.0752
.6	1932.2051	155.8230	.6	2256.4175	168.3894
.7	1940.0042	156.1372	.7	2264.8448	168.7035
.8	1947.8189	156.4513	.8	2273.2879	169.0177
.9	1955.6493	156.7655	.9	2281.7466	169.3318
50.0	1963.4954	157.0796	54.0	2290.2210	169.6460
.1	1971.3572	157.3938	.1	2298.7112	169.9602
.2	1979.2348	157.7080	.2	2307.2171	170.2743
.3	1987.1280	158.0221	.3	2315.7386	170.5885
.4	1995.0370	158.3363	.4	2324.2759	170.9026
.5	2002.9617	158.6504	.5	2332.8289	171.2168
.6	2010.9020	158.9646	.6	2341.3976	171.5310
.7	2018.8581	159.2787	.7	2349.9820	171.8451
.8	2026.8299	159.5929	.8	2358.5821	172.1593
.9	2034.8174	159.9071	.9	2367.1979	172.4735
51.0	2042.8206	160.2212	55.0	2375.8294	172.7876
.1	2050.8395	160.5354	.1	2384.4767	173.1017
.2	2058.8742	160.8495	.2	2393.1396	173.4159
.3	2066.9245	161.1637	.3	2401.8183	173.7301
.4	2074.9905	161.4779	.4	2410.5126	174.0442
.5	2083.0723	161.7920	.5	2419.2227	174.3584
.6	2091.1697	162.1062	.6	2427.9485	174.6726
.7	2099.2829	162.4203	.7	2436.6899	174.9867
.8	2107.4118	162.7345	.8	2445.4471	175.3009
.9	2115.5563	163.0487	.9	2454.2200	175.6150

AREAS and CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Area.	Circum.	Diam.	Area.	Circum.
56.0	2463.0086	175.9292	60.0	2827.4334	188.4956
.1	2471.8130	176.2433	.1	2836.8660	188.8097
.2	2480.6330	176.5575	.2	2846.3144	189.1239
.3	2489.4687	176.8717	.3	2855.7784	189.4380
.4	2498.3201	177.1858	.4	2865.2582	189.7522
.5	2507.1873	177.5000	.5	2874.7536	190.0664
.6	2516.0701	177.8141	.6	2884.2648	190.3805
.7	2524.9687	178.1283	.7	2893.7917	190.6947
.8	2533.8830	178.4425	.8	2903.3343	191.0088
.9	2542.8129	178.7566	.9	2912.8926	191.3230
57.0	2551.7586	179.0708	61.0	2922.4666	191.6372
.1	2560.7200	179.3849	.1	2932.0563	191.9513
.2	2569.6971	179.6991	.2	2941.6617	192.2655
.3	2578.6899	180.0133	.3	2951.2828	192.5796
.4	2587.6985	180.3274	.4	2960.9197	192.8938
.5	2596.7227	180.6416	.5	2970.5722	193.2079
.6	2605.7626	180.9557	.6	2980.2405	193.5221
.7	2614.8183	181.2699	.7	2989.9244	193.8363
.8	2623.8896	181.5841	.8	2999.6241	194.1504
.9	2632.9767	181.8982	.9	3009.3395	194.4646
58.0	2642.0794	182.2124	62.0	3019.0705	194.7787
.1	2651.1979	182.5265	.1	3028.8173	195.0929
.2	2660.3321	182.8407	.2	3038.5798	195.4071
.3	2669.4820	183.1549	.3	3048.3580	195.7212
.4	2678.6476	183.4690	.4	3058.1520	196.0354
.5	2687.8289	183.7832	.5	3067.9616	196.3495
.6	2697.0259	184.0973	.6	3077.7869	196.6637
.7	2706.2386	184.4115	.7	3087.6279	196.9779
.8	2715.4670	184.7256	.8	3097.4847	197.2920
.9	2724.7112	185.0398	.9	3107.3571	197.6062
59.0	2733.9710	185.3540	63.0	3117.2453	197.9203
.1	2743.2466	185.6681	.1	3127.1492	198.2345
.2	2752.5378	185.9823	.2	3137.0688	198.5487
.3	2761.8448	186.2964	.3	3147.0040	198.8628
.4	2771.1675	186.6106	.4	3156.9550	199.1770
.5	2780.5058	186.9248	.5	3166.9217	199.4911
.6	2789.8599	187.2389	.6	3176.9043	199.8053
.7	2799.2297	187.5531	.7	3186.9023	200.1195
.8	2808.6152	187.8672	.8	3196.9161	200.4336
.9	2818.0165	188.1814	.9	3206.9456	200.7478

AREAS and CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Area.	Circum.	Diam.	Area.	Circum.
64.0	3216.9909	201.0620	68.0	3631.6811	213.6283
.1	3227.0518	201.3761	.1	3642.3704	213.9425
.2	3237.1285	201.6902	.2	3653.0754	214.2566
.3	3247.2222	202.0044	.3	3663.7960	214.5708
.4	3257.3289	202.3186	.4	3674.5324	214.8849
.5	3267.4527	202.6327	.5	3685.2845	215.1991
.6	3277.5922	202.9469	.6	3696.0523	215.5133
.7	3287.7474	203.2610	.7	3706.8359	215.8274
.8	3297.9183	203.5752	.8	3717.6351	216.1416
.9	3308.1049	203.8894	.9	3728.4500	216.4556
65.0	3318.3072	204.2035	69.0	3739.2807	216.7699
.1	3328.5253	204.5176	.1	3750.1270	217.0841
.2	3338.7590	204.8318	.2	3760.9891	217.3982
.3	3349.0085	205.1460	.3	3771.8668	217.7124
.4	3359.2736	205.4602	.4	3782.7603	218.0265
.5	3369.5545	205.7743	.5	3793.6695	218.3407
.6	3379.8510	206.0885	.6	3804.5944	218.6548
.7	3390.1633	206.4026	.7	3815.5350	218.9690
.8	3400.4913	206.7168	.8	3826.4913	219.2832
.9	3410.8350	207.0310	.9	3837.4633	219.5973
66.0	3421.1944	207.3451	70.0	3848.4510	219.9115
.1	3431.5695	207.6593	.1	3859.4544	220.2256
.2	3441.9603	207.9734	.2	3870.4736	220.5398
.3	3452.3669	208.2876	.3	3881.5084	220.8540
.4	3462.7891	208.6017	.4	3892.5590	221.1681
.5	3473.2270	208.9159	.5	3903.6252	221.4823
.6	3483.6807	209.2301	.6	3914.7072	221.7964
.7	3494.1500	209.5442	.7	3925.8049	222.1106
.8	3504.6351	209.8584	.8	3936.9182	222.4248
.9	3515.1359	210.1725	.9	3948.0473	222.7389
67.0	3525.6524	210.4867	71.0	3959.1921	223.0531
.1	3536.1845	210.8009	.1	3970.3526	223.3672
.2	3546.7324	211.1150	.2	3981.5289	223.6814
.3	3557.2960	211.4292	.3	3992.7208	223.9956
.4	3567.8754	211.7433	.4	4003.9284	224.3097
.5	3578.4704	212.0575	.5	4015.1518	224.6239
.6	3589.0811	212.3717	.6	4026.3908	224.9380
.7	3599.7075	212.6858	.7	4037.6456	225.2522
.8	3610.3497	213.0000	.8	4048.9160	225.5664
.9	3621.0075	213.3141	.9	4060.2022	225.8805

AREAS and CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Area.	Circum.	Diam.	Area.	Circum.
72.0	4071.5041	226.1947	76.0	4536.4598	238.7610
.1	4082.8217	226.5088	.1	4548.4057	239.0752
.2	4094.1550	226.8230	.2	4560.3673	239.3894
.3	4105.5040	227.1371	.3	4572.3446	239.7035
.4	4116.8687	227.4513	.4	4584.3377	240.0177
.5	4128.2491	227.7655	.5	4596.3464	240.3318
.6	4139.6452	228.0796	.6	4608.3708	240.6460
.7	4151.0571	228.3938	.7	4620.4110	240.9602
.8	4162.4846	228.7079	.8	4632.4669	241.2743
.9	4173.9279	229.0221	.9	4644.5384	241.5885
73.0	4185.3868	229.3363	77.0	4656.6257	241.9026
.1	4196.8615	229.6504	.1	4668.7287	242.2168
.2	4208.3519	229.9646	.2	4680.8474	242.5310
.3	4219.8579	230.2787	.3	4692.9818	242.8451
.4	4231.3797	230.5929	.4	4705.1319	243.1592
.5	4242.9172	230.9071	.5	4717.2977	243.4734
.6	4254.4704	231.2212	.6	4729.4792	243.7876
.7	4266.0394	231.5354	.7	4741.6765	244.1017
.8	4277.6240	231.8495	.8	4753.8894	244.4159
.9	4289.2243	232.1637	.9	4766.1181	244.7301
74.0	4300.8403	232.4779	78.0	4778.3624	245.0442
.1	4312.4721	232.7920	.1	4790.6225	245.3584
.2	4324.1195	233.1062	.2	4802.8983	245.6725
.3	4335.7827	233.4203	.3	4815.1897	245.9867
.4	4347.4616	233.7345	.4	4827.4969	246.3009
.5	4359.1562	234.0487	.5	4839.8198	246.6150
.6	4370.8664	234.3628	.6	4852.1584	246.9292
.7	4382.5924	234.6770	.7	4864.5128	247.2433
.8	4394.3341	234.9911	.8	4876.8828	247.5575
.9	4406.0916	235.3053	.9	4889.2685	247.8717
75.0	4417.8647	235.6194	79.0	4901.6699	248.1858
.1	4429.6535	235.9336	.1	4914.0871	248.5000
.2	4441.4580	236.2478	.2	4926.5199	248.8141
.3	4453.2783	236.5619	.3	4938.9685	249.1283
.4	4465.1142	236.8761	.4	4951.4328	249.4425
.5	4476.9659	237.1902	.5	4963.9127	249.7566
.6	4488.8332	237.5044	.6	4976.4084	250.0708
.7	4500.7163	237.8186	.7	4988.9198	250.3850
.8	4512.6151	238.1327	.8	5001.4469	250.6991
.9	4524.5296	238.4469	.9	5013.9897	251.0133

AREAS and CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Area.	Circum.	Diam.	Area.	Circum.
80.0	5026.5482	251.3274	84.0	5541.7694	263.8938
.1	5039.1225	251.6416	.1	5554.9720	264.2079
.2	5051.7124	251.9557	.2	5568.1902	264.5221
.3	5064.3180	252.2699	.3	5581.4242	264.8363
.4	5076.9394	252.5840	.4	5594.6739	265.1514
.5	5089.5764	252.8982	.5	5607.9392	265.4646
.6	5102.2292	253.2124	.6	5621.2203	265.7787
.7	5114.8977	253.5265	.7	5634.5171	266.0929
.8	5127.5819	253.8407	.8	5647.8296	266.4071
.9	5140.2818	254.1548	.9	5661.1578	266.7212
81.0	5152.9973	254.4690	85.0	5674.5017	267.0354
.1	5165.7287	254.7832	.1	5687.8614	267.3495
.2	5178.4757	255.0973	.2	5701.2367	267.6637
.3	5191.2384	255.4115	.3	5714.6277	267.9779
.4	5204.0168	255.7256	.4	5728.0345	268.2920
.5	5216.8110	256.0398	.5	5741.4569	268.6062
.6	5229.6208	256.3540	.6	5754.8951	268.9203
.7	5242.4463	256.6681	.7	5768.3490	269.2345
.8	5255.2876	256.9823	.8	5781.8185	269.5486
.9	5268.1446	257.2966	.9	5795.3038	269.8628
82.0	5281.0173	257.6106	86.0	5808.8048	270.1770
.1	5293.9056	257.9247	.1	5822.3215	270.4911
.2	5306.8097	258.2389	.2	5835.8539	270.8053
.3	5319.7295	258.5531	.3	5849.4020	271.1194
.4	5332.6650	258.8672	.4	5862.9659	271.4336
.5	5345.6162	259.1814	.5	5876.5454	271.7478
.6	5358.5832	259.4956	.6	5890.1407	272.0619
.7	5371.5658	259.8097	.7	5903.7516	272.3761
.8	5384.5641	260.1239	.8	5917.3783	272.6902
.9	5397.5782	260.4380	.9	5931.0206	273.0044
83.0	5410.6079	260.7522	87.0	5944.6787	273.3186
.1	5423.6534	261.0663	.1	5958.3525	273.6327
.2	5436.7146	261.3805	.2	5972.0420	273.9469
.3	5449.7915	261.6947	.3	5985.7472	274.2610
.4	5462.8840	262.0088	.4	5999.4681	274.5752
.5	5475.9923	262.3230	.5	6013.2047	274.8894
.6	5489.1163	262.6371	.6	6026.9570	275.2035
.7	5502.2561	262.9513	.7	6040.7250	275.5177
.8	5515.4115	263.2655	.8	6054.5088	275.8318
.9	5528.5826	263.5796	.9	6068.3082	276.1460

AREAS and CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Area.	Circum.	Diam.	Area.	Circum.
88.0	6082.1234	276.4602	92.0	6647.6101	289.0265
.1	6095.9542	276.7743	.1	6662.0692	289.3407
.2	6109.8008	277.0885	.2	6676.5441	289.6548
.3	6123.6631	277.4026	.3	6691.0347	289.9690
.4	6137.5411	277.7168	.4	6705.5410	290.2832
.5	6151.4348	278.0309	.5	6720.0630	290.5973
.6	6165.3442	278.3451	.6	6734.6008	290.9115
.7	6179.2693	278.6593	.7	6749.1542	291.2256
.8	6193.2101	278.9740	.8	6763.7233	291.5398
.9	6207.1666	279.2876	.9	6778.3082	291.8540
89.0	6221.1389	279.6017	93.0	6792.9087	292.1681
.1	6235.1268	279.9159	.1	6807.5250	292.4823
.2	6249.1304	280.2301	.2	6822.1569	292.7964
.3	6263.1498	280.5442	.3	6836.8046	293.1106
.4	6277.1849	280.8584	.4	6851.4680	293.4248
.5	6291.2356	281.1725	.5	6866.1471	293.7389
.6	6305.3021	281.4867	.6	6880.8419	294.0531
.7	6319.3843	281.8009	.7	6895.5524	294.3672
.8	6333.4822	282.1150	.8	6910.2786	294.6814
.9	6347.5958	282.4292	.9	6925.0205	294.9956
90.0	6361.7251	282.7433	94.0	6939.7782	295.3097
.1	6375.8701	283.0575	.1	6954.5515	295.6239
.2	6390.0309	283.3717	.2	6969.3106	295.9380
.3	6404.2073	283.6858	.3	6984.1453	296.2522
.4	6418.3995	284.0000	.4	6998.9658	296.5663
.5	6432.6073	284.3141	.5	7013.8019	296.8805
.6	6446.8309	284.6283	.6	7028.6538	297.1947
.7	6461.0701	284.9425	.7	7043.5214	297.5088
.8	6475.3251	285.2566	.8	7058.4047	297.8230
.9	6489.5958	285.5708	.9	7073.3033	298.1371
91.0	6503.8822	285.8849	95.0	7088.2184	298.4513
.1	6518.1843	286.1991	.1	7103.1488	298.7655
.2	6532.5021	286.5133	.2	7118.1950	299.0796
.3	6546.8356	286.8274	.3	7133.0568	299.3938
.4	6561.1848	287.1416	.4	7148.0343	299.7079
.5	6575.5498	287.4557	.5	7163.0276	300.0221
.6	6589.9304	287.7699	.6	7178.0366	300.3363
.7	6604.3268	288.0840	.7	7193.0612	300.6504
.8	6618.7388	288.3982	.8	7208.1016	300.9646
.9	6633.1666	288.7124	.9	7223.1577	301.2787

AREAS and CIRCUMFERENCES OF CIRCLES.

(CONTINUED.)

Diam.	Area.	Circum.	Diam.	Area.	Circum.
96.0	7238.2295	301.5929	98.0	7542.9640	307.8761
.1	7253.3170	301.9071	.1	7558.3656	308.1902
.2	7268.4202	302.2212	.2	7573.7830	308.5044
.3	7283.5391	302.5354	.3	7589.2161	308.8186
.4	7298.6737	302.8405	.4	7604.6648	309.1327
.5	7313.8240	303.1637	.5	7620.1293	309.4469
.6	7328.9901	303.4779	.6	7635.6095	309.7610
.7	7344.1718	303.7920	.7	7651.1054	310.0752
.8	7359.3693	304.1062	.8	7666.6170	310.3894
.9	7374.5824	304.4203	.9	7682.1444	310.7035
97.0	7389.8113	304.7345	99.0	7697.6893	311.0177
.1	7405.0559	305.0486	.1	7713.2461	311.3318
.2	7420.3162	305.3628	.2	7728.8206	311.6460
.3	7435.5922	305.6770	.3	7744.4107	311.9602
.4	7450.8839	305.9911	.4	7760.0166	312.2743
.5	7466.1913	306.3053	.5	7775.6382	312.5885
.6	7481.5144	306.6194	.6	7791.2754	312.9026
.7	7496.8532	306.9336	.7	7806.9284	313.2168
.8	7512.2078	307.2478	.8	7822.5971	313.5309
.9	7527.5780	307.5619	.9	7838.2815	313.8451
			100.0	7853.9816	314.1593

To compute the area or circumference of a diameter greater than 100 and less than 1001:

Take out the area or circumference from table as though the number had one decimal, and move the decimal point two places to the right for the area, and one place for the circumference.

EXAMPLE—Wanted the area and circumference of 567. The tabular area for 56.7 is 2524.9687, and circumference 178.1283. Therefore area for 567 = 252496.87 and circumference = 1781.283.

To compute the area or circumference of a diameter greater than 1000:

Divide by a factor, as 2, 3, 4, 5, etc., if practicable, that will leave a quotient to be found in table, then multiply the tabular area of the quotient by the *square* of the factor, or the tabular circumference by the factor.

EXAMPLE—Wanted the area and circumference of 2109. Dividing by 3, the quotient is 703, for which the area is 388150.84 and the circumference 2208.54. Therefore area of 2109 = 388150.84 × 9 = 3493357.56 and circumference = 2208.54 × 3 = 6625.62.

LOGARITHMS OF NUMBERS.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	40
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	37
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	33
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	31
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	29
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	27
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	25
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	24
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	23
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	21
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	21
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	20
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	19
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	18
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	17
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	17
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	16
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	16
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	15
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	14
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	14
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	13
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	13
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	13
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	13
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	12
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	12
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	12
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	12
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	11
No.	0	1	2	3	4	5	6	7	8	9	Diff.

LOGARITHMS OF NUMBERS—Continued.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	11
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	10
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	10
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	10
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	10
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	10
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	9
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	9
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	9
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	9
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	9
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	8
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	8
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	8
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	8
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	8
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	8
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	7
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	8
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	8
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	7
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	7
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	6
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	7
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	7
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	6
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	7
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	6
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	6
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	6
No.	0	1	2	3	4	5	6	7	8	9	Diff.

LOGARITHMS OF NUMBERS—Continued.

No.	0	1	2	3	4	5	6	7	8	9	Diff.
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	7
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	6
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	6
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	6
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	6
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	6
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	6
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	6
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	6
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	6
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	5
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	5
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	5
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	5
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	5
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	5
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	5
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	5
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	4
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	4
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	5
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	5
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	4
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	4
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	5
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	5
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	4
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	4
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	4
No.	0	1	2	3	4	5	6	7	8	9	Diff.

NATURAL SINES, TANGENTS AND SECANTS,

Advancing by 10 min.

Deg.	Min.	Sine.	Tangent.	Secant.	Deg.	Min.	Sine.	Tangent.	Secant.
0	00	.0000	.0000	1.0000	5	00	.0872	.0875	1.0038
	10	.0029	.0029	1.0000		10	.0901	.0904	1.0041
	20	.0058	.0058	1.0000		20	.0929	.0934	1.0043
	30	.0087	.0087	1.0000		30	.0958	.0963	1.0046
	40	.0116	.0116	1.0001		40	.0987	.0992	1.0049
	50	.0145	.0145	1.0001		50	.1016	.1022	1.0052
1	00	.0175	.0175	1.0002	6	00	.1045	.1051	1.0055
	10	.0204	.0204	1.0002		10	.1074	.1080	1.0058
	20	.0233	.0233	1.0003		20	.1103	.1110	1.0061
	30	.0262	.0262	1.0003		30	.1132	.1139	1.0065
	40	.0291	.0291	1.0004		40	.1161	.1169	1.0068
	50	.0320	.0320	1.0005		50	.1190	.1198	1.0072
2	00	.0349	.0349	1.0006	7	00	.1219	.1228	1.0075
	10	.0378	.0378	1.0007		10	.1248	.1257	1.0079
	20	.0407	.0407	1.0008		20	.1276	.1287	1.0082
	30	.0436	.0437	1.0010		30	.1305	.1317	1.0086
	40	.0465	.0466	1.0011		40	.1334	.1346	1.0090
	50	.0494	.0495	1.0012		50	.1363	.1376	1.0094
3	00	.0523	.0524	1.0014	8	00	.1392	.1405	1.0098
	10	.0552	.0553	1.0015		10	.1421	.1435	1.0102
	20	.0581	.0582	1.0017		20	.1449	.1465	1.0107
	30	.0610	.0612	1.0019		30	.1478	.1495	1.0111
	40	.0640	.0641	1.0021		40	.1507	.1524	1.0116
	50	.0669	.0670	1.0022		50	.1536	.1554	1.0120
4	00	.0698	.0699	1.0024	9	00	.1564	.1584	1.0125
	10	.0727	.0729	1.0027		10	.1593	.1614	1.0129
	20	.0756	.0758	1.0029		20	.1622	.1644	1.0134
	30	.0785	.0787	1.0031		30	.1650	.1673	1.0139
	40	.0814	.0816	1.0033		40	.1679	.1703	1.0144
	50	.0843	.0846	1.0036		50	.1708	.1733	1.0149

NATURAL SINES, TANGENTS AND SECANTS.

(CONTINUED.)

Deg.	Min.	Sine.	Tangent.	Secant.	Deg.	Min.	Sine.	Tangent.	Secant.
10	00	.1736	.1763	1.0154	**15**	00	.2588	.2679	1.0353
	10	.1765	.1793	1.0160		10	.2616	.2711	1.0361
	20	.1794	.1823	1.0165		20	.2644	.2742	1.0369
	30	.1822	.1853	1.0170		30	.2672	.2773	1.0377
	40	.1851	.1883	1.0176		40	.2700	.2805	1.0386
	50	.1880	.1914	1.0181		50	.2728	.2836	1.0394
11	00	.1908	.1944	1.0187	**16**	00	.2756	.2867	1.0403
	10	.1937	.1974	1.0193		10	.2784	.2899	1.0412
	20	.1965	.2004	1.0199		20	.2812	.2931	1.0421
	30	.1994	.2035	1.0205		30	.2840	.2962	1.0429
	40	.2022	.2065	1.0211		40	.2868	.2994	1.0439
	50	.2051	.2095	1.0217		50	.2896	.3026	1.0448
12	00	.2079	.2126	1.0223	**17**	00	.2924	.3057	1.0457
	10	.2108	.2156	1.0230		10	.2952	.3089	1.0466
	20	.2136	.2186	1.0236		20	.2979	.3121	1.0476
	30	.2164	.2217	1.0243		30	.3007	.3153	1.0485
	40	.2193	.2247	1.0249		40	.3035	.3185	1.0495
	50	.2221	.2278	1.0256		50	.3062	.3217	1.0505
13	00	.2250	.2309	1.0263	**18**	00	.3090	.3249	1.0515
	10	.2278	.2339	1.0270		10	.3118	.3281	1.0525
	20	.2306	.2370	1.0277		20	.3145	.3314	1.0535
	30	.2334	.2401	1.0284		30	.3173	.3346	1.0545
	40	.2363	.2432	1.0291		40	.3201	.3378	1.0555
	50	.2391	.2462	1.0299		50	.3228	.3411	1.0566
14	00	.2419	.2493	1.0306	**19**	00	.3256	.3443	1.0576
	10	.2447	.2524	1.0314		10	.3283	.3476	1.0587
	20	.2476	.2555	1.0321		20	.3311	.3508	1.0598
	30	.2504	.2586	1.0329		30	.3338	.3541	1.0608
	40	.2532	.2617	1.0337		40	.3365	.3574	1.0619
	50	.2560	.2648	1.0345		50	.3393	.3607	1.0631

NATURAL SINES, TANGENTS AND SECANTS.

(CONTINUED.)

Deg.	Min.	Sine.	Tangent.	Secant.	Deg.	Min.	Sine.	Tangent.	Secant.
20	00	.3420	.3640	1.0642	25	00	.4226	.4663	1.1034
	10	.3448	.3673	1.0653		10	.4253	.4699	1.1049
	20	.3475	.3706	1.0665		20	.4279	.4734	1.1064
	30	.3502	.3739	1.0676		30	.4305	.4770	1.1079
	40	.3529	.3772	1.0688		40	.4331	.4806	1.1095
	50	.3557	.3805	1.0700		50	.4358	.4841	1.1110
21	00	.3584	.3839	1.0711	26	00	.4384	.4877	1.1126
	10	.3611	.3872	1.0723		10	.4410	.4913	1.1142
	20	.3638	.3906	1.0736		20	.4436	.4950	1.1158
	30	.3665	.3939	1.0748		30	.4462	.4986	1.1174
	40	.3692	.3973	1.0760		40	.4488	.5022	1.1190
	50	.3719	.4006	1.0773		50	.4514	.5059	1.1207
22	00	.3746	.4040	1.0785	27	00	.4540	.5095	1.1223
	10	.3773	.4074	1.0798		10	.4566	.5132	1.1240
	20	.3800	.4108	1.0811		20	.4592	.5169	1.1257
	30	.3827	.4142	1.0824		30	.4617	.5206	1.1274
	40	.3854	.4176	1.0837		40	.4643	.5243	1.1291
	50	.3881	.4210	1.0850		50	.4669	.5280	1.1308
23	00	.3907	.4245	1.0864	28	00	.4695	.5317	1.1326
	10	.3934	.4279	1.0877		10	.4720	.5354	1.1343
	20	.3961	.4314	1.0891		20	.4746	.5392	1.1361
	30	.3987	.4348	1.0904		30	.4772	.5430	1.1379
	40	.4014	.4383	1.0918		40	.4797	.5467	1.1397
	50	.4041	.4417	1.0932		50	.4823	.5505	1.1415
24	00	.4067	.4452	1.0946	29	00	.4848	.5543	1.1434
	10	.4094	.4487	1.0961		10	.4874	.5581	1.1452
	20	.4120	.4522	1.0975		20	.4899	.5619	1.1471
	30	.4147	.4557	1.0989		30	.4924	.5658	1.1490
	40	.4173	.4592	1.1004		40	.4950	.5696	1.1509
	50	.4200	.4628	1.1019		50	.4975	.5735	1.1528

NATURAL SINES, TANGENTS AND SECANTS.

(CONTINUED.)

Deg.	Min.	Sine.	Tangent.	Secant.	Deg.	Min.	Sine.	Tangent.	Secant.
30	00	.5000	.5774	1.1547	35	00	.5736	.7002	1.2208
	10	.5025	.5812	1.1566		10	.5760	.7046	1.2233
	20	.5050	.5851	1.1586		20	.5783	.7089	1.2258
	30	.5075	.5890	1.1606		30	.5807	.7133	1.2283
	40	.5100	.5930	1.1626		40	.5831	.7177	1.2309
	50	.5125	.5969	1.1646		50	.5854	.7221	1.2335
31	00	.5150	.6009	1.1666	36	00	.5878	.7265	1.2361
	10	.5175	.6048	1.1687		10	.5901	.7310	1.2387
	20	.5200	.6088	1.1707		20	.5925	.7355	1.2413
	30	.5225	.6128	1.1728		30	.5948	.7400	1.2440
	40	.5250	.6168	1.1749		40	.5972	.7445	1.2467
	50	.5275	.6208	1.1770		50	.5995	.7490	1.2494
32	00	.5299	.6249	1.1792	37	00	.6018	.7536	1.2521
	10	.5324	.6289	1.1813		10	.6041	.7581	1.2549
	20	.5348	.6330	1.1835		20	.6065	.7627	1.2577
	30	.5373	.6371	1.1857		30	.6088	.7673	1.2605
	40	.5398	.6412	1.1879		40	.6111	.7720	1.2633
	50	.5422	.6453	1.1901		50	.6134	.7766	1.2661
33	00	.5446	.6494	1.1924	38	00	.6157	.7813	1.2690
	10	.5471	.6536	1.1946		10	.6180	.7860	1.2719
	20	.5495	.6577	1.1969		20	.6202	.7907	1.2748
	30	.5519	.6619	1.1992		30	.6225	.7954	1.2778
	40	.5544	.6661	1.2015		40	.6248	.8002	1.2808
	50	.5568	.6703	1.2039		50	.6271	.8050	1.2837
34	00	.5592	.6745	1.2062	39	00	.6293	.8098	1.2868
	10	.5616	.6787	1.2086		10	.6316	.8146	1.2898
	20	.5640	.6830	1.2110		20	.6338	.8195	1.2929
	30	.5664	.6873	1.2134		30	.6361	.8243	1.2960
	40	.5688	.6916	1.2158		40	.6383	.8292	1.2991
	50	.5712	.6959	1.2183		50	.6406	.8342	1.3022

NATURAL SINES, TANGENTS AND SECANTS.

(CONTINUED.)

Deg.	Min.	Sine.	Tangent.	Secant.	Deg.	Min.	Sine.	Tangent.	Secant.
40	00	.6428	.8391	1.3054	45	00	.7071	1.0000	1.4142
	10	.6450	.8441	1.3086		10	.7092	1.0058	1.4183
	20	.6472	.8491	1.3118		20	.7112	1.0117	1.4225
	30	.6494	.8541	1.3151		30	.7133	1.0176	1.4267
	40	.6517	.8591	1.3184		40	.7153	1.0235	1.4310
	50	.6539	.8642	1.3217		50	.7173	1.0295	1.4352
41	00	.6561	.8693	1.3250	46	00	.7193	1.0355	1.4396
	10	.6583	.8744	1.3284		10	.7214	1.0416	1.4439
	20	.6604	.8796	1.3318		20	.7234	1.0477	1.4483
	30	.6626	.8847	1.3352		30	.7254	1.0538	1.4527
	40	.6648	.8899	1.3386		40	.7274	1.0599	1.4572
	50	.6670	.8952	1.3421		50	.7294	1.0661	1.4617
42	00	.6691	.9004	1.3456	47	00	.7314	1.0724	1.4663
	10	.6713	.9057	1.3492		10	.7333	1.0786	1.4709
	20	.6734	.9110	1.3527		20	.7353	1.0850	1.4755
	30	.6756	.9163	1.3563		30	.7373	1.0913	1.4802
	40	.6777	.9217	1.3600		40	.7392	1.0977	1.4849
	50	.6799	.9271	1.3636		50	.7412	1.1041	1.4897
43	00	.6820	.9325	1.3673	48	00	.7431	1.1106	1.4945
	10	.6841	.9380	1.3711		10	.7451	1.1171	1.4993
	20	.6862	.9435	1.3748		20	.7470	1.1237	1.5042
	30	.6884	.9490	1.3786		30	.7490	1.1303	1.5092
	40	.6905	.9545	1.3824		40	.7509	1.1369	1.5141
	50	.6926	.9601	1.3863		50	.7528	1.1436	1.5192
44	00	.6947	.9657	1.3902	49	00	.7547	1.1504	1.5243
	10	.6967	.9713	1.3941		10	.7566	1.1571	1.5294
	20	.6988	.9770	1.3980		20	.7585	1.1640	1.5345
	30	.7009	.9827	1.4020		30	.7604	1.1708	1.5398
	40	.7030	.9884	1.4061		40	.7623	1.1778	1.5450
	50	.7050	.9942	1.4101		50	.7642	1.1847	1.5504

NATURAL SINES, TANGENTS AND SECANTS.

(CONTINUED.)

Deg.	Min.	Sine.	Tangent.	Secant.	Deg.	Min.	Sine.	Tangent.	Secant.
50	00	.7660	1.1918	1.5557	**55**	00	.8192	1.4281	1.7434
	10	.7679	1.1988	1.5611		10	.8208	1.4370	1.7507
	20	.7698	1.2059	1.5666		20	.8225	1.4460	1.7581
	30	.7716	1.2131	1.5721		30	.8241	1.4550	1.7655
	40	.7735	1.2203	1.5777		40	.8258	1.4641	1.7730
	50	.7753	1.2276	1.5833		50	.8274	1.4733	1.7806
51	00	.7771	1.2349	1.5890	**56**	00	.8290	1.4826	1.7883
	10	.7790	1.2423	1.5948		10	.8307	1.4919	1.7960
	20	.7808	1.2497	1.6005		20	.8323	1.5013	1.8039
	30	.7826	1.2572	1.6064		30	.8339	1.5108	1.8118
	40	.7844	1.2647	1.6123		40	.8355	1.5204	1.8198
	50	.7862	1.2723	1.6183		50	.8371	1.5301	1.8279
52	00	.7880	1.2799	1.6243	**57**	00	.8387	1.5399	1.8361
	10	.7898	1.2876	1.6303		10	.8403	1.5497	1.8443
	20	.7916	1.2954	1.6365		20	.8418	1.5597	1.8527
	30	.7934	1.3032	1.6427		30	.8434	1.5697	1.8612
	40	.7951	1.3111	1.6489		40	.8450	1.5798	1.8699
	50	.7969	1.3190	1.6553		50	.8465	1.5900	1.8783
53	00	.7986	1.3270	1.6616	**58**	00	.8480	1.6003	1.8871
	10	.8004	1.3351	1.6681		10	.8496	1.6107	1.8959
	20	.8021	1.3432	1.6746		20	.8511	1.6213	1.9048
	30	.8039	1.3514	1.6812		30	.8526	1.6319	1.9139
	40	.8056	1.3597	1.6878		40	.8542	1.6426	1.9230
	50	.8073	1.3680	1.6945		50	.8557	1.6534	1.9323
54	00	.8090	1.3764	1.7013	**59**	00	.8572	1.6643	1.9416
	10	.8107	1.3848	1.7081		10	.8587	1.6753	1.9511
	20	.8124	1.3934	1.7151		20	.8601	1.6864	1.9606
	30	.8141	1.4019	1.7221		30	.8616	1.6977	1.9703
	40	.8158	1.4106	1.7291		40	.8631	1.7090	1.9801
	50	.8175	1.4193	1.7362		50	.8646	1.7205	1.9900

NATURAL SINES, TANGENTS AND SECANTS.

(CONTINUED.)

Deg.	Min.	Sine.	Tangent.	Secant.	Deg.	Min.	Sine.	Tangent.	Secant.
60	00	.8660	1.7321	2.0000	65	00	.9063	2.1445	2.3662
	10	.8675	1.7437	2.0101		10	.9075	2.1609	2.3811
	20	.8689	1.7556	2.0204		20	.9088	2.1775	2.3961
	30	.8704	1.7675	2.0308		30	.9100	2.1943	2.4114
	40	.8718	1.7796	2.0413		40	.9112	2.2113	2.4269
	50	.8732	1.7917	2.0519		50	.9124	2.2286	2.4426
61	00	.8746	1.8040	2.0627	66	00	.9135	2.2460	2.4586
	10	.8760	1.8165	2.0736		10	.9147	2.2637	2.4748
	20	.8774	1.8291	2.0846		20	.9159	2.2817	2.4912
	30	.8788	1.8418	2.0957		30	.9171	2.2998	2.5078
	40	.8802	1.8546	2.1070		40	.9182	2.3183	2.5247
	50	.8816	1.8676	2.1185		50	.9194	2.3369	2.5419
62	00	.8829	1.8807	2.1301	67	00	.9205	2.3559	2.5593
	10	.8843	1.8940	2.1418		10	.9216	2.3750	2.5770
	20	.8857	1.9074	2.1537		20	.9228	2.3945	2.5949
	30	.8870	1.9210	2.1657		30	.9239	2.4141	2.6131
	40	.8884	1.9347	2.1786		40	.9250	2.4342	2.6316
	50	.8897	1.9486	2.1902		50	.9261	2.4545	2.6504
63	00	.8910	1.9626	2.2027	68	00	.9272	2.4751	2.6695
	10	.8923	1.9768	2.2153		10	.9283	2.4960	2.6888
	20	.8936	1.9912	2.2282		20	.9293	2.5172	2.7085
	30	.8949	2.0057	2.2412		30	.9304	2.5386	2.7285
	40	.8962	2.0204	2.2543		40	.9315	2.5605	2.7488
	50	.8975	2.0353	2.2677		50	.9325	2.5826	2.7695
64	00	.8988	2.0503	2.2812	69	00	.9336	2.6051	2.7904
	10	.9001	2.0655	2.2949		10	.9346	2.6279	2.8117
	20	.9013	2.0809	2.3088		20	.9356	2.6511	2.8334
	30	.9026	2.0965	2.3228		30	.9367	2.6746	2.8555
	40	.9038	2.1123	2.3371		40	.9377	2.6985	2.8779
	50	.9051	2.1283	2.3515		50	.9387	2.7228	2.9006

NATURAL SINES, TANGENTS AND SECANTS

(CONTINUED.)

Deg.	Min.	Sine.	Tangent.	Secant.	Deg.	Min.	Sine.	Tangent.	Secant.
70	00	.9397	2.7475	2.9238	75	00	.9659	3.7321	3.8637
	10	.9407	2.7725	2.9474		10	.9667	3.7760	3.9061
	20	.9417	2.7980	2.9713		20	.9674	3.8208	3.9495
	30	.9426	2.8239	2.9957		30	.9681	3.8667	3.9939
	40	.9436	2.8502	3.0206		40	.9689	3.9136	4.0394
	50	.9446	2.8770	3.0458		50	.9696	3.9617	4.0859
71	00	.9455	2.9042	3.0716	76	00	.9703	4.0108	4.1336
	10	.9465	2.9319	3.0977		10	.9710	4.0611	4.1824
	20	.9474	2.9600	3.1244		20	.9717	4.1126	4.2324
	30	.9483	2.9887	3.1515		30	.9724	4.1653	4.2837
	40	.9492	3.0178	3.1792		40	.9730	4.2193	4.3362
	50	.9502	3.0475	3.2074		50	.9737	4.2747	4.3901
72	00	.9511	3.0777	3.2361	77	00	.9744	4.3315	4.4454
	10	.9520	3.1084	3.2653		10	.9750	4.3897	4.5022
	20	.9528	3.1397	3.2951		20	.9757	4.4494	4.5604
	30	.9537	3.1716	3.3255		30	.9763	4.5107	4.6202
	40	.9546	3.2041	3.3565		40	.9769	4.5736	4.6817
	50	.9555	3.2371	3.3881		50	.9775	4.6382	4.7448
73	00	.9563	3.2709	3.4203	78	00	.9781	4.7046	4.8097
	10	.9572	3.3052	3.4532		10	.9787	4.7729	4.8765
	20	.9580	3.3402	3.4867		20	.9793	4.8430	4.9452
	30	.9588	3.3759	3.5209		30	.9799	4.9152	5.0159
	40	.9596	3.4124	3.5559		40	.9805	4.9894	5.0886
	50	.9605	3.4495	3.5915		50	.9811	5.0658	5.1636
74	00	.9613	3.4874	3.6280	79	00	.9816	5.1446	5.2408
	10	.9621	3.5261	3.6652		10	.9822	5.2257	5.3205
	20	.9628	3.5656	3.7032		20	.9827	5.3093	5.4026
	30	.9636	3.6059	3.7420		30	.9833	5.3955	5.4874
	40	.9644	3.6470	3.7817		40	.9838	5.4845	5.5749
	50	.9652	3.6891	3.8222		50	.9843	5.5764	5.6653

NATURAL SINES, TANGENTS AND SECANTS.

(CONTINUED.)

Deg.	Min.	Sine.	Tangent.	Secant.	Deg.	Min.	Sine.	Tangent.	Secant.
80	00	.9848	5.6713	5.7588	85	00	.9962	11.430	11.474
	10	.9853	5.7694	5.8554		10	.9964	11.826	11.868
	20	.9858	5.8708	5.9554		20	.9967	12.251	12.291
	30	.9863	5.9758	6.0589		30	.9969	12.706	12.745
	40	.9868	6.0844	6.1661		40	.9971	13.197	13.235
	50	.9872	6.1970	6.2772		50	.9974	13.727	13.763
81	00	.9877	6.3138	6.3925	86	00	.9976	14.301	14.336
	10	.9881	6.4348	6.5121		10	.9978	14.924	14.958
	20	.9886	6.5606	6.6363		20	.9980	15.605	15.637
	30	.9890	6.6912	6.7655		30	.9981	16.350	16.380
	40	.9894	6.8269	6.8998		40	.9983	17.169	17.198
	50	.9899	6.9682	7.0396		50	.9985	18.075	18.103
82	00	.9903	7.1154	7.1853	87	00	.9986	19.081	19.107
	10	.9907	7.2687	7.3372		10	.9988	20.206	20.230
	20	.9911	7.4287	7.4957		20	.9989	21.470	21.494
	30	.9914	7.5958	7.6613		30	.9990	22.904	22.926
	40	.9918	7.7704	7.8344		40	.9992	24.542	24.562
	50	.9922	7.9530	8.0156		50	.9993	26.432	26.451
83	00	.9925	8.1443	8.2055	88	00	.9994	28.636	28.654
	10	.9929	8.3450	8.4047		10	.9995	31.242	31.258
	20	.9932	8.5555	8.6138		20	.9996	34.368	34.382
	30	.9936	8.7769	8.8337		30	.9997	38.188	38.202
	40	.9939	9.0098	9.0652		40	.9997	42.964	42.976
	50	.9942	9.2553	9.3092		50	.9998	49.104	49.114
84	00	.9945	9.5144	9.5668	89	00	.9998	57.290	57.299
	10	.9948	9.7882	9.8391		10	.9999	68.750	68.757
	20	.9951	10.0780	10.1275		20	.9999	85.940	85.946
	30	.9954	10.3854	10.4334		30	1.0000	114.589	114.593
	40	.9957	10.7119	10.7585		40	1.0000	171.885	171.888
	50	.9959	11.0594	11.1045		50	1.0000	343.774	343.775
					90	00	1.0000	Infinite.	Infinite.

SQUARES, CUBES AND RECIPROCALS.

Nos.	Squares.	Cubes.	Reciprocals.	Nos.	Squares.	Cubes.	Reciprocals.
1	1	1	1.000000000	51	26 01	132 651	.019607843
2	4	8	.500000000	52	27 04	140 608	.019230769
3	9	27	.333333333	53	28 09	148 877	.018867925
4	16	64	.250000000	54	29 16	157 464	.018518519
5	25	125	.200000000	55	30 25	166 375	.018181818
6	36	216	.166666667	56	31 36	175 616	.017857143
7	49	343	.142857143	57	32 49	185 193	.017543860
8	64	512	.125000000	58	33 64	195 112	.017241379
9	81	729	.111111111	59	34 81	205 379	.016949153
10	1 00	1 000	.100000000	60	36 00	216 000	.016666667
11	1 21	1 331	.090909091	61	37 21	226 981	.016393443
12	1 44	1 728	.083333333	62	38 44	238 328	.016129032
13	1 69	2 197	.076923077	63	39 69	250 047	.015873016
14	1 96	2 744	.071428571	64	40 96	262 144	.015625000
15	2 25	3 375	.066666667	65	42 25	274 625	.015384615
16	2 56	4 096	.062500000	66	43 56	287 496	.015151515
17	2 89	4 913	.058823529	67	44 89	300 763	.014925373
18	3 24	5 832	.055555556	68	46 24	314 432	.014705882
19	3 61	6 859	.052631579	69	47 61	328 509	.014492754
20	4 00	8 000	.050000000	70	49 00	343 000	.014285714
21	4 41	9 261	.047619048	71	50 41	357 911	.014084507
22	4 84	10 648	.045454545	72	51 84	373 248	.013888889
23	5 29	12 167	.043478260	73	53 29	389 017	.013698630
24	5 76	13 824	.041666667	74	54 76	405 224	.013513514
25	6 25	15 625	.040000000	75	56 25	421 875	.013333333
26	6 76	17 576	.038461538	76	57 76	438 976	.013157895
27	7 29	19 683	.037037037	77	59 29	456 533	.012987013
28	7 84	21 952	.035714286	78	60 84	474 552	.012820513
29	8 41	24 389	.034482759	79	62 41	493 039	.012658228
30	9 00	27 000	.033333333	80	64 00	512 000	.012500000
31	9 61	29 791	.032258065	81	65 61	531 441	.012345679
32	10 24	32 768	.031250000	82	67 24	551 368	.012195122
33	10 89	35 937	.030303030	83	68 89	571 787	.012048193
34	11 56	39 304	.029411765	84	70 56	592 704	.011904762
35	12 25	42 875	.028571429	85	72 25	614 125	.011764706
36	12 96	46 656	.027777778	86	73 96	636 056	.011627907
37	13 69	50 653	.027027027	87	75 69	658 503	.011494253
38	14 44	54 872	.026315789	88	77 44	681 472	.011363636
39	15 21	59 319	.025641026	89	79 21	704 969	.011235955
40	16 00	64 000	.025000000	90	81 00	729 000	.011111111
41	16 81	68 921	.024390244	91	82 81	753 571	.010989011
42	17 64	74 088	.023809524	92	84 64	778 688	.010869565
43	18 49	79 507	.023255814	93	86 49	804 357	.010752688
44	19 36	85 184	.022727273	94	88 36	830 584	.010638298
45	20 25	91 125	.022222222	95	90 25	857 375	.010526316
46	21 16	97 336	.021739130	96	92 16	884 736	.010416667
47	22 09	103 823	.021276600	97	94 09	912 673	.010309278
48	23 04	110 592	.020833333	98	96 04	941 192	.010204082
49	24 01	117 649	.020408163	99	98 01	970 299	.010101010
50	25 00	125 000	.020000000	100	1 00 00	1 000 000	.010000000

SQUARES, CUBES AND RECIPROCALS—Continued.

Nos.	Squares.	Cubes.	Reciprocals.	Nos.	Squares.	Cubes.	Reciprocals.
101	1 02 01	1 030 301	.009900990	151	2 28 01	3 442 951	.006622517
102	1 04 04	1 061 208	.009803922	152	2 31 04	3 511 808	.006578947
103	1 06 09	1 092 727	.009708738	153	2 34 09	3 581 577	.006535948
104	1 08 16	1 124 864	.009615385	154	2 37 16	3 652 264	.006493506
105	1 10 25	1 157 625	.009523810	155	2 40 25	3 723 875	.006451613
106	1 12 36	1 191 016	.009433962	156	2 43 36	3 796 416	.006410256
107	1 14 49	1 225 043	.009345794	157	2 46 49	3 869 893	.006369427
108	1 16 64	1 259 712	.009259259	158	2 49 64	3 944 312	.006329114
109	1 18 81	1 295 029	.009174312	159	2 52 81	4 019 679	.006289308
110	1 21 00	1 331 000	.009090909	160	2 56 00	4 096 000	.006250000
111	1 23 21	1 367 631	.009009009	161	2 59 21	4 173 281	.006211180
112	1 25 44	1 404 928	.008928571	162	2 62 44	4 251 528	.006172840
113	1 27 69	1 442 897	.008849558	163	2 65 69	4 330 747	.006134969
114	1 29 96	1 481 544	.008771930	164	2 68 96	4 410 944	.006097561
115	1 32 25	1 520 875	.008695652	165	2 72 25	4 492 125	.006060606
116	1 34 56	1 560 896	.008620690	166	2 75 56	4 574 296	.006024096
117	1 36 89	1 601 613	.008547009	167	2 78 89	4 657 463	.005988024
118	1 39 24	1 643 032	.008474576	168	2 82 24	4 741 632	.005952381
119	1 41 61	1 685 159	.008403361	169	2 85 61	4 826 809	.005917160
120	1 44 00	1 728 000	.008333333	170	2 89 00	4 913 000	.005882353
121	1 46 41	1 771 561	.008264463	171	2 92 41	5 000 211	.005847953
122	1 48 84	1 815 848	.008196721	172	2 95 84	5 088 448	.005813953
123	1 51 29	1 860 867	.008130081	173	2 99 29	5 177 717	.005780347
124	1 53 76	1 906 624	.008064516	174	3 02 76	5 268 024	.005747126
125	1 56 25	1 953 125	.008000000	175	3 06 25	5 359 375	.005714286
126	1 58 76	2 000 376	.007936508	176	3 09 76	5 451 776	.005681818
127	1 61 29	2 048 383	.007874016	177	3 13 29	5 545 233	.005649718
128	1 63 84	2 097 152	.007812500	178	3 16 84	5 639 752	.005617978
129	1 66 41	2 146 689	.007751938	179	3 20 41	5 735 339	.005586592
130	1 69 00	2 197 000	.007692308	180	3 24 00	5 832 000	.005555556
131	1 71 61	2 248 091	.007633588	181	3 27 61	5 929 741	.005524862
132	1 74 24	2 299 968	.007575758	182	3 31 24	6 028 568	.005494505
133	1 76 89	2 352 637	.007518797	183	3 34 89	6 128 487	.005464481
134	1 79 56	2 406 104	.007462687	184	3 38 56	6 229 504	.005434783
135	1 82 25	2 460 375	.007407407	185	3 42 25	6 331 625	.005405405
136	1 84 96	2 515 456	.007352941	186	3 45 96	6 434 856	.005376344
137	1 87 69	2 571 353	.007299270	187	3 49 69	6 539 203	.005347594
138	1 90 44	2 628 072	.007246377	188	3 53 44	6 644 672	.005319149
139	1 93 21	2 685 619	.007194245	189	3 57 21	6 751 269	.005291005
140	1 96 00	2 744 000	.007142857	190	3 61 00	6 859 000	.005263158
141	1 98 81	2 803 221	.007092199	191	3 64 81	6 967 871	.005235602
142	2 01 64	2 863 288	.007042254	192	3 68 64	7 077 888	.005208333
143	2 04 49	2 924 207	.006993007	193	3 72 49	7 189 057	.005181347
144	2 07 36	2 985 984	.006944444	194	3 76 36	7 301 384	.005154639
145	2 10 25	3 048 625	.006896552	195	3 80 25	7 414 875	.005128205
146	2 13 16	3 112 136	.006849315	196	3 84 16	7 529 536	.005102041
147	2 16 09	3 176 523	.006802721	197	3 88 09	7 645 373	.005076142
148	2 19 04	3 241 792	.006756757	198	3 92 04	7 762 392	.005050505
149	2 22 01	3 307 949	.006711409	199	3 96 01	7 880 599	.005025126
150	2 25 00	3 375 000	.006666667	200	4 00 00	8 000 000	.005000000

SQUARES, CUBES AND RECIPROCALS—CONTINUED.

Nos.	Squares.	Cubes.	Reciprocals.	Nos.	Squares.	Cubes.	Reciprocals.
201	4 04 01	8 120 601	.004975124	251	6 30 01	15 813 251	.003934064
202	4 08 04	8 242 408	.004950495	252	6 35 04	16 003 008	.003968254
203	4 12 09	8 365 427	.004926108	253	6 40 09	16 194 277	.003952569
204	4 16 16	8 489 664	.004901961	254	6 45 16	16 387 064	.003937008
205	4 20 25	8 615 125	.004878049	255	6 50 25	16 581 375	.003921569
206	4 24 36	8 741 816	.004854369	256	6 55 36	16 777 216	.003906250
207	4 28 49	8 869 743	.004830918	257	6 60 49	16 974 593	.003891051
208	4 32 64	8 998 912	.004807692	258	6 65 64	17 173 512	.003875969
209	4 36 81	9 129 329	.004784689	259	6 70 81	17 373 979	.003861004
210	4 41 00	9 261 000	.004761905	260	6 76 00	17 576 000	.003846154
211	4 45 21	9 393 931	.004739336	261	6 81 21	17 779 581	.003831418
212	4 49 44	9 528 128	.004716981	262	6 86 44	17 984 728	.003816794
213	4 53 69	9 663 597	.004694836	263	6 91 69	18 191 447	.003802281
214	4 57 96	9 800 344	.004672897	264	6 96 96	18 399 744	.003787879
215	4 62 25	9 938 375	.004651163	265	7 02 25	18 609 625	.003773585
216	4 66 56	10 077 696	.004629630	266	7 07 56	18 821 096	.003759398
217	4 70 89	10 218 313	.004608295	267	7 12 89	19 034 163	.003745318
218	4 75 24	10 360 232	.004587156	268	7 18 24	19 248 832	.003731343
219	4 79 61	10 503 459	.004566210	269	7 23 61	19 465 109	.003717472
220	4 84 00	10 648 000	.004545455	270	7 29 00	19 683 000	.003703704
221	4 88 41	10 793 861	.004524887	271	7 34 41	19 902 511	.003690037
222	4 92 84	10 941 048	.004504505	272	7 39 84	20 123 648	.003676471
223	4 97 29	11 089 567	.004484305	273	7 45 29	20 346 417	.003663004
224	5 01 76	11 239 424	.004464286	274	7 50 76	20 570 824	.003649635
225	5 06 25	11 390 625	.004444444	275	7 56 25	20 796 875	.003366364
226	5 10 76	11 543 176	.004424779	276	7 61 76	21 024 576	.003623188
227	5 15 29	11 697 083	.004405286	277	7 67 29	21 253 933	.003610108
228	5 19 84	11 852 352	.004385965	278	7 72 84	21 484 952	.003597122
229	5 24 41	12 008 989	.004366812	279	7 78 41	21 717 639	.003584229
230	5 29 00	12 167 000	.004347826	280	7 84 00	21 952 000	.003571429
231	5 33 61	12 326 391	.004329004	281	7 89 61	22 188 041	.003558719
232	5 38 24	12 487 168	.004310345	282	7 95 24	22 425 768	.003546099
233	5 42 89	12 649 337	.004291845	283	8 00 89	22 665 187	.003533569
234	5 47 56	12 812 904	.004273504	284	8 06 56	22 906 304	.003521127
235	5 52 25	12 977 875	.004255319	285	8 12 25	23 149 125	.003508772
236	5 56 96	13 144 256	.004237288	286	8 17 96	23 393 656	.003496503
237	5 61 69	13 312 053	.004219409	287	8 23 69	23 639 903	.003484321
238	5 66 44	13 481 272	.004201681	288	8 29 44	23 887 872	.003472222
239	5 71 21	13 651 919	.004184100	289	8 35 21	24 137 569	.003460208
240	5 76 00	13 824 000	.004166667	290	8 41 00	24 389 000	.003448276
241	5 80 81	13 997 521	.004149378	291	8 46 81	24 642 171	.003436426
242	5 85 64	14 172 488	.004132231	292	8 52 64	24 897 088	.003424658
243	5 90 49	14 348 907	.004115226	293	8 58 49	25 153 757	.003412969
244	5 95 36	14 526 784	.004098361	294	8 64 36	25 412 184	.003401361
245	6 00 25	14 706 125	.004081633	295	8 70 25	25 672 375	.003389831
246	6 05 16	14 886 936	.004065041	296	8 76 16	25 934 336	.003378378
247	6 10 09	15 069 223	.004048583	297	8 82 09	26 198 073	.003367003
248	6 15 04	15 252 992	.004032258	298	8 88 04	26 463 592	.003355705
249	6 20 01	15 438 249	.004016064	299	8 94 01	26 730 899	.003344482
250	6 25 00	15 625 000	.004000000	300	9 00 00	27 000 000	.003333333

SQUARES, CUBES AND RECIPROCALS—CONTINUED.

Nos.	Squares	Cubes.	Reciprocals.	Nos.	Squares.	Cubes.	Reciprocals.
301	9 06 01	27 270 901	.003322259	351	12 32 01	43 243 551	.002849003
302	9 12 04	27 543 608	.003311258	352	12 39 04	43 614 208	.002840909
303	9 18 09	27 818 127	.003300330	353	12 46 09	43 986 977	.002832861
304	9 24 16	28 094 464	.003289474	354	12 53 16	44 361 864	.002824859
305	9 30 25	28 372 625	.003278689	355	12 60 25	44 738 875	.002816901
306	9 36 36	28 652 616	.003267974	356	12 67 36	45 118 016	.002808989
307	9 42 49	28 934 443	.003257329	357	12 74 49	45 499 293	.002801120
308	9 48 64	29 218 112	.003246753	358	12 81 64	45 882 712	.002793296
309	9 54 81	29 503 629	.003236246	359	12 88 81	46 268 279	.002785515
310	9 61 00	29 791 000	.003225806	360	12 96 00	46 656 000	.002777778
311	9 67 21	30 080 231	.003215434	361	13 03 21	47 045 881	.002770083
312	9 73 44	30 371 328	.003205128	362	13 10 44	47 437 928	.002762431
313	9 79 69	30 664 297	.003194888	363	13 17 69	47 832 147	.002754821
314	9 85 96	30 959 144	.003184713	364	13 24 96	48 228 544	.002747253
315	9 92 25	31 255 875	.003174603	365	13 32 25	48 627 125	.002739726
316	9 98 56	31 554 496	.003164557	366	13 39 56	49 027 896	.002732240
317	10 04 89	31 855 013	.003154574	367	13 46 89	49 430 863	.002724796
318	10 11 24	32 157 432	.003144654	368	13 54 24	49 836 032	.002717391
319	10 17 61	32 461 759	.003134796	369	13 61 61	50 243 409	.002710027
320	10 24 00	32 768 000	.003125000	370	13 69 00	50 653 000	.002702703
321	10 30 41	33 076 161	.003115265	371	13 76 41	51 064 811	.002695418
322	10 36 84	33 386 248	.003105590	372	13 83 84	51 478 848	.002688172
323	10 43 29	33 698 267	.003095975	373	13 91 29	51 895 117	.002680965
324	10 49 76	34 012 224	.003086420	374	13 98 76	52 313 624	.002673797
325	10 56 25	34 328 125	.003076923	375	14 06 25	52 734 375	.002666667
326	10 62 76	34 645 976	.003067485	376	14 13 76	53 157 376	.002659574
327	10 69 29	34 965 783	.003058104	377	14 21 29	53 582 633	.002652520
328	10 75 84	35 287 552	.003048780	378	14 28 84	54 010 152	.002645503
329	10 82 41	35 611 289	.003039514	379	14 36 41	54 439 939	.002638522
330	10 89 00	35 937 000	.003030303	380	14 44 00	54 872 000	.002631579
331	10 95 61	36 264 691	.003021148	381	14 51 61	55 306 341	.002624672
332	11 02 24	36 594 368	.003012048	382	14 59 24	55 742 968	.002617801
333	11 08 89	36 926 037	.003003003	383	14 66 89	56 181 887	.002610966
334	11 15 56	37 259 704	.002994012	384	14 74 56	56 623 104	.002604167
335	11 22 25	37 595 375	.002985075	385	14 82 25	57 066 625	.002597403
336	11 28 96	37 933 056	.002976190	386	14 89 96	57 512 456	.002590674
337	11 35 69	38 272 753	.002967359	387	14 97 69	57 960 603	.002583979
338	11 42 44	38 614 472	.002958580	388	15 05 44	58 411 072	.002577320
339	11 49 21	38 958 219	.002949853	389	15 13 21	58 863 869	.002570694
340	11 56 00	39 304 000	.002941176	390	15 21 00	59 319 000	.002564103
341	11 62 81	39 651 821	.002932551	391	15 28 81	59 776 471	.002557545
342	11 69 64	40 001 688	.002923977	392	15 36 64	60 236 288	.002551020
343	11 76 49	40 353 607	.0029 5452	393	15 44 49	60 698 457	.002544529
344	11 83 36	40 707 584	.002906977	394	15 52 36	61 162 984	.002538071
345	11 90 25	41 063 625	.002898551	395	15 60 25	61 629 875	.002531646
346	11 97 16	41 421 736	.002890173	396	15 68 16	62 099 136	.002525253
347	12 04 09	41 781 923	.002881844	397	15 76 09	62 570 773	.002518892
348	12 11 04	42 144 192	.002873563	398	15 84 04	63 044 792	.002512563
349	12 18 01	42 508 549	.002865330	399	15 92 01	63 521 199	.002506266
350	12 25 00	42 875 000	.002857143	400	16 00 00	64 000 000	.002500000

SQUARES, CUBES AND RECIPROCALS—CONTINUED.

Nos.	Squares.	Cubes.	Reciprocals.	Nos.	Squares.	Cubes.	Reciprocals.
401	16 08 01	64 481 201	.002493766	451	20 34 01	91 733 851	.002217295
402	16 16 04	64 964 808	.002487562	452	20 43 04	92 345 408	.002212389
403	16 24 09	65 450 827	.002481390	453	20 52 09	92 959 677	.002207506
404	16 32 16	65 939 264	.002475248	454	20 61 16	93 576 664	.002202643
405	16 40 25	66 430 125	.002469136	455	20 70 25	94 196 375	.002197802
406	16 48 36	66 923 416	.002463054	456	20 79 36	94 818 816	.002192982
407	16 56 49	67 419 143	.002457002	457	20 88 49	95 443 993	.002188184
408	16 64 64	67 917 312	.002450980	458	20 97 64	96 071 912	.002183406
409	16 72 81	68 417 929	.002444988	459	21 06 81	96 702 579	.002178649
410	16 81 00	68 921 000	.002439024	460	21 16 00	97 336 000	.002173913
411	16 89 21	69 426 531	.002433090	461	21 25 21	97 972 181	.002169197
412	16 97 44	69 934 528	.002427184	462	21 34 44	98 611 128	.002164502
413	17 05 69	70 444 997	.002421308	463	21 43 69	99 252 847	.002159827
414	17 13 96	70 957 944	.002415459	464	21 52 96	99 897 344	.002155172
415	17 22 25	71 473 375	.002409639	465	21 62 25	100 544 625	.002150538
416	17 30 56	71 991 296	.002403846	466	21 71 56	101 194 696	.002145923
417	17 38 89	72 511 713	.002398082	467	21 80 89	101 847 563	.002141328
418	17 47 24	73 034 632	.002392344	468	21 90 24	102 503 232	.002136752
419	17 55 61	73 560 059	.002386635	469	21 99 61	103 161 709	.002132196
420	17 64 00	74 088 000	.002380952	470	22 09 00	103 823 000	.002127660
421	17 72 41	74 618 461	.002375297	471	22 18 41	104 487 111	.002123142
422	17 80 84	75 151 448	.002369668	472	22 27 84	105 154 048	.002118644
423	17 89 29	75 686 967	.002364066	473	22 37 29	105 823 817	.002114165
424	17 97 76	76 225 024	.002358491	474	22 46 76	106 496 424	.002109705
425	18 06 25	76 765 625	.002352941	475	22 56 25	107 171 875	.002105263
426	18 14 76	77 308 776	.002347418	476	22 65 76	107 850 176	.002100840
427	18 23 29	77 854 483	.002341920	477	22 75 29	108 531 333	.002096436
428	18 31 84	78 402 752	.002336449	478	22 84 84	109 215 352	.002092050
429	18 40 41	78 953 589	.002331002	479	22 94 41	109 902 239	.002087683
430	18 49 00	79 507 000	.002325581	480	23 04 00	110 592 000	.002083333
431	18 57 61	80 062 991	.002320186	481	23 13 61	111 284 641	.002079002
432	18 66 24	80 621 568	.002314815	482	23 23 24	111 980 168	.002074689
433	18 74 89	81 182 737	.002309469	483	23 32 89	112 678 587	.002070393
434	18 83 56	81 746 504	.002304147	484	23 42 56	113 379 904	.002066116
435	18 92 25	82 312 875	.002298851	485	23 52 25	114 084 125	.002061856
436	19 00 96	82 881 856	.002293578	486	23 61 96	114 791 256	.002057613
437	19 09 69	83 453 453	.002288330	487	23 71 69	115 501 303	.002053388
438	19 18 44	84 027 672	.002283105	488	23 81 44	116 214 272	.002049180
439	19 27 21	84 604 519	.002277904	489	23 91 21	116 930 169	.002044990
440	19 36 00	85 184 000	.002272727	490	24 01 00	117 649 000	.002040816
441	19 44 81	85 766 121	.002267574	491	24 10 81	118 370 771	.002036660
442	19 53 64	86 350 888	.002262443	492	24 20 64	119 095 488	.002032520
443	19 62 49	86 938 307	.002257336	493	24 30 49	119 823 157	.002028398
444	19 71 36	87 528 384	.002252252	494	24 40 36	120 553 784	.002024291
445	19 80 25	88 121 125	.002247191	495	24 50 25	121 287 375	.002020202
446	19 89 16	88 716 536	.002242152	496	24 60 16	122 023 936	.002016129
447	19 98 09	89 314 623	.002237136	497	24 70 09	122 763 473	.002012072
448	20 07 04	89 915 392	.002232143	498	24 80 04	123 505 992	.002008032
449	20 16 01	90 518 849	.002227171	499	24 90 01	124 251 499	.002004008
450	20 25 00	91 125 000	.002222222	500	25 00 00	125 000 000	.002000000

SQUARES, CUBES AND RECIPROCALS—Continued.

Nos.	Squares.	Cubes.	Reciprocals.	Nos.	Squares.	Cubes.	Reciprocals.
501	25 10 01	125 751 501	.001996008	551	30 36 01	167 284 151	.001814882
502	25 20 04	126 506 008	.001992032	552	30 47 04	168 196 608	.001811594
503	25 30 09	127 263 527	.001988072	553	30 58 09	169 112 377	.001808318
504	25 40 16	128 024 064	.001984127	554	30 69 16	170 031 464	.001805054
505	25 50 25	128 787 625	.001980198	555	30 80 25	170 953 875	.001801802
506	25 60 36	129 554 216	.001976285	556	30 91 36	171 879 616	.001798561
507	25 70 49	130 323 843	.001972387	557	31 02 49	172 808 693	.001795332
508	25 80 64	131 096 512	.001968504	558	31 13 64	173 741 112	.001792115
509	25 90 81	131 872 229	.001964637	559	31 24 81	174 676 879	.001788909
510	26 01 00	132 651 000	.001960784	560	31 36 00	175 616 000	.001785714
511	26 11 21	133 432 831	.001956947	561	31 47 21	176 558 481	.001782531
512	26 21 44	134 217 728	.001953125	562	31 58 44	177 504 328	.001779359
513	26 31 69	135 005 697	.001949318	563	31 69 69	178 453 547	.001776199
514	26 41 96	135 796 744	.001945525	564	31 80 96	179 406 144	.001773050
515	26 52 25	136 590 875	.001941748	565	31 92 25	180 362 125	.001769912
516	26 62 56	137 388 096	.001937984	566	32 03 56	181 321 496	.001766784
517	26 72 89	138 188 413	.001934236	567	32 14 89	182 284 263	.001763668
518	26 83 24	138 991 832	.001930502	568	32 26 24	183 250 432	.001760563
519	26 93 61	139 798 359	.001926782	569	32 37 61	184 220 009	.001757469
520	27 04 00	140 608 000	.001923077	570	32 49 00	185 193 000	.001754386
521	27 14 41	141 420 761	.001919386	571	32 60 41	186 169 411	.001751313
522	27 24 84	142 236 648	.001915709	572	32 71 84	187 149 248	.001748252
523	27 35 29	143 055 667	.001912046	573	32 83 29	188 132 517	.001745201
524	27 45 76	143 877 824	.001908397	574	32 94 76	189 119 224	.001742160
525	27 56 25	144 703 125	.001904762	575	33 06 25	190 109 375	.001739130
526	27 66 76	145 531 576	.001901141	576	33 17 76	191 102 976	.001736111
527	27 77 29	146 363 183	.001897533	577	33 29 29	192 100 033	.001733102
528	27 87 84	147 197 952	.001893939	578	33 40 84	193 100 552	.001730104
529	27 98 41	148 035 889	.001890359	579	33 52 41	194 104 539	.001727116
530	28 09 00	148 877 000	.001886792	580	33 64 00	195 112 000	.001724138
531	28 19 61	149 721 291	.001883239	581	33 75 61	196 122 941	.001721170
532	28 30 24	150 568 768	.001879699	582	33 87 24	197 137 368	.001718213
533	28 40 89	151 419 437	.001876173	583	33 98 89	198 155 287	.001715266
534	28 51 56	152 273 304	.001872659	584	34 10 56	199 176 704	.001712329
535	28 62 25	153 130 375	.001869159	585	34 22 25	200 201 625	.001709402
536	28 72 96	153 990 656	.001865672	586	34 33 96	201 230 056	.001706485
537	28 83 69	154 854 153	.001862197	587	34 45 69	202 262 003	.001703578
538	28 94 44	155 720 872	.001858736	588	34 57 44	203 297 472	.001700680
539	29 05 21	156 590 819	.001855288	589	34 69 21	204 336 469	.001697793
540	29 16 00	157 464 000	.001851852	590	34 81 00	205 379 000	.001694915
541	29 26 81	158 340 421	.001848429	591	34 92 81	206 425 071	.001692047
542	29 37 64	159 220 088	.001845018	592	35 04 64	207 474 688	.001689189
543	29 48 49	160 103 007	.001841621	593	35 16 49	208 527 857	.001686341
544	29 59 36	160 989 184	.001838235	594	35 28 36	209 584 584	.001683502
545	29 70 25	161 878 625	.001834862	595	35 40 25	210 644 875	.001680672
546	29 81 16	162 771 336	.001831502	596	35 52 16	211 708 736	.001677852
547	29 92 09	163 667 323	.001828154	597	35 64 09	212 776 173	.001675042
548	30 03 04	164 566 592	.001824818	598	35 76 04	213 847 192	.001672241
549	30 14 01	165 469 149	.001821494	599	35 88 01	214 921 799	.001669449
550	30 25 00	166 375 000	.001818182	600	36 00 00	216 000 000	.001666667

SQUARES, CUBES AND RECIPROCALS—Continued.

Nos.	Squares.	Cubes.	Reciprocals.	Nos.	Squares.	Cubes.	Reciprocals.
601	36 12 01	217 081 801	.001663894	651	42 38 01	275 894 451	.001536098
602	36 24 04	218 167 208	.001661130	652	42 51 04	277 167 808	.001533742
603	36 36 09	219 256 227	.001658375	653	42 64 09	278 445 077	.001531394
604	36 48 16	220 348 864	.001655629	654	42 77 16	279 726 264	.001529052
605	36 60 25	221 445 125	.001652893	655	42 90 25	281 011 375	.001526718
606	36 72 36	222 545 016	.001650165	656	43 03 36	282 300 416	.001524390
607	36 84 49	223 648 543	.001647446	657	43 16 49	283 593 393	.001522070
608	36 96 64	224 755 712	.001644737	658	43 29 64	284 890 312	.001519757
609	37 08 81	225 866 529	.001642036	659	43 42 81	286 191 179	.001517451
610	37 21 00	226 981 000	.001639344	660	43 56 00	287 496 000	.001515152
611	37 33 21	228 099 131	.001636661	661	43 69 21	288 804 781	.001512859
612	37 45 44	229 220 928	.001633987	662	43 82 44	290 117 528	.001510574
613	37 57 69	230 346 397	.001631321	663	43 95 69	291 434 247	.001508296
614	37 69 96	231 475 544	.001628664	664	44 08 96	292 754 944	.001506024
615	37 82 25	232 608 375	.001626016	665	44 22 25	294 079 625	.001503759
616	37 94 56	233 744 896	.001623377	666	44 35 56	295 408 296	.001501502
617	38 06 89	234 885 113	.001620746	667	44 48 89	296 740 963	.001499250
618	38 19 24	236 029 032	.001618123	668	44 62 24	298 077 632	.001497006
619	38 31 61	237 176 659	.001615509	669	44 75 61	299 418 309	.001494768
620	38 44 00	238 328 000	.001612903	670	44 89 00	300 763 000	.001492537
621	38 56 41	239 483 061	.001610306	671	45 02 41	302 111 711	.001490313
622	38 68 84	240 641 848	.001607717	672	45 15 84	303 464 448	.001488095
623	38 81 29	241 804 367	.001605136	673	45 29 29	304 821 217	.001485884
624	38 93 76	242 970 624	.001602564	674	45 42 76	306 182 024	.001483680
625	39 06 25	244 140 625	.001600000	675	45 56 25	307 546 875	.001481481
626	39 18 76	245 314 376	.001597444	676	45 69 76	308 915 776	.001479290
627	39 31 29	246 491 883	.001594896	677	45 83 29	310 288 733	.001477105
628	39 43 84	247 673 152	.001592357	678	45 96 84	311 665 752	.001474926
629	39 56 41	248 858 189	.001589825	679	46 10 41	313 046 839	.001472754
630	39 69 00	250 047 000	.001587302	680	46 24 00	314 432 000	.001470588
631	39 81 61	251 239 591	.001584786	681	46 37 61	315 821 241	.001468429
632	39 94 24	252 435 968	.001582278	682	46 51 24	317 214 568	.001466276
633	40 06 89	253 636 137	.001579779	683	46 64 89	318 611 987	.001464129
634	40 19 56	254 840 104	.001577287	684	46 78 56	320 013 504	.001461988
635	40 32 25	256 047 875	.001574803	685	46 92 25	321 419 125	.001459854
636	40 44 96	257 259 456	.001572327	686	47 05 96	322 828 856	.001457726
637	40 57 69	258 474 853	.001569859	687	47 19 69	324 242 703	.001455604
638	40 70 44	259 694 072	.001567398	688	47 33 44	325 660 672	.001453488
639	40 83 21	260 917 119	.001564945	689	47 47 21	327 082 769	.001451379
640	40 96 00	262 144 000	.001562500	690	47 61 00	328 509 000	.001449275
641	41 08 81	263 374 721	.001560062	691	47 74 81	329 939 371	.001447178
642	41 21 64	264 609 288	.001557632	692	47 88 64	331 373 888	.001445087
643	41 34 49	265 847 707	.001555210	693	48 02 49	332 812 557	.001443001
644	41 47 36	267 089 984	.001552795	694	48 16 36	334 255 384	.001440922
645	41 60 25	268 336 125	.001550388	695	48 30 25	335 702 375	.001438849
646	41 73 16	269 586 136	.001547988	696	48 44 16	337 153 536	.001436782
647	41 86 09	270 840 023	.001545595	697	48 58 09	338 608 873	.001434720
648	41 99 04	272 097 792	.001543210	698	48 72 04	340 068 392	.001432665
649	42 12 01	273 359 449	.001540832	699	48 86 01	341 532 099	.001430615
650	42 25 00	274 625 000	.001538462	700	49 00 00	343 000 000	.001428571

SQUARES, CUBES AND RECIPROCALS—CONTINUED.

Nos.	Squares.	Cubes.	Reciprocals.	Nos.	Squares.	Cubes.	Reciprocals.
701	49 14 01	344 472 101	.001426534	751	56 40 01	423 564 751	.001331558
702	49 28 04	345 948 408	.001424501	752	56 55 04	425 259 008	.001329787
703	49 42 09	347 428 927	.001422475	753	56 70 09	426 957 777	.001328021
704	49 56 16	348 913 664	.001420455	754	56 85 16	428 661 064	.001326260
705	49 70 25	350 402 625	.001418440	755	57 00 25	430 368 875	.001324503
706	49 84 36	351 895 816	.001416431	756	57 15 36	432 081 216	.001322751
707	49 98 49	353 393 243	.001414427	757	57 30 49	433 798 093	.001321004
708	50 12 64	354 894 912	.001412429	758	57 45 64	435 519 512	.001319261
709	50 26 81	356 400 829	.001410437	759	57 60 81	437 245 479	.001317523
710	50 41 00	357 911 000	.001408451	760	57 76 00	438 976 000	.001315789
711	50 55 21	359 425 431	.001406470	761	57 91 21	440 711 081	.001314060
712	50 69 44	360 944 128	.001404494	762	58 06 44	442 450 728	.001312336
713	50 83 69	362 467 097	.001402525	763	58 21 69	444 194 947	.001310616
714	50 97 96	363 994 344	.001400560	764	58 36 96	445 943 744	.001308901
715	51 12 25	365 525 875	.001398601	765	58 52 25	447 697 125	.001307190
716	51 26 56	367 061 696	.001396648	766	58 67 56	449 455 096	.001305483
717	51 40 89	368 601 813	.001394700	767	58 82 89	451 217 663	.001303781
718	51 55 24	370 146 232	.001392758	768	58 98 24	452 984 832	.001302083
719	51 69 61	371 694 959	.001390821	769	59 13 61	454 756 609	.001300390
720	51 84 00	373 248 000	.001388889	770	59 29 00	456 533 000	.001298701
721	51 98 41	374 805 361	.001386963	771	59 44 41	458 314 011	.001297017
722	52 12 84	376 367 048	.001385042	772	59 59 84	460 099 648	.001295337
723	52 27 29	377 933 067	.001383126	773	59 75 29	461 889 917	.001293661
724	52 41 76	379 503 424	.001381215	774	59 90 76	463 684 824	.001291990
725	52 56 25	381 078 125	.001379310	775	60 06 25	465 484 375	.001290323
726	52 70 76	382 657 176	.001377410	776	60 21 76	467 288 576	.001288660
727	52 85 29	384 240 583	.001375516	777	60 37 29	469 097 433	.001287001
728	52 99 84	385 828 352	.001373626	778	60 52 84	470 910 952	.001285347
729	53 14 41	387 420 489	.001371742	779	60 68 41	472 729 139	.001283697
730	53 29 00	389 017 000	.001369863	780	60 84 00	474 552 000	.001282051
731	53 43 61	390 617 891	.001367989	781	60 99 61	476 379 541	.001280410
732	53 58 24	392 223 168	.001366120	782	61 15 24	478 211 768	.001278772
733	53 72 89	393 832 837	.001364256	783	61 30 89	480 048 687	.001277139
734	53 87 56	395 446 904	.001362398	784	61 46 56	481 890 304	.001275510
735	54 02 25	397 065 375	.001360544	785	61 62 25	483 736 625	.001273885
736	54 16 96	398 688 256	.001358696	786	61 77 96	485 587 656	.001272265
737	54 31 69	400 315 553	.001356852	787	61 93 69	487 443 403	.001270648
738	54 46 44	401 947 272	.001355014	788	62 09 44	489 303 872	.001269036
739	54 61 21	403 583 419	.001353180	789	62 25 21	491 169 069	.001267427
740	54 76 00	405 224 000	.001351351	790	62 41 00	493 039 000	.001265823
741	54 90 81	406 869 021	.001349528	791	62 56 81	494 913 671	.001264223
742	55 05 64	408 518 488	.001347709	792	62 72 64	496 793 088	.001262626
743	55 20 49	410 172 407	.001345895	793	62 88 49	498 677 257	.001261034
744	55 35 36	411 830 784	.001344086	794	63 04 36	500 566 184	.001259446
745	55 50 25	413 493 625	.001342282	795	63 20 25	502 459 875	.001257862
746	55 65 16	415 160 936	.001340483	796	63 36 16	504 358 336	.001256281
747	55 80 09	416 832 723	.001338688	797	63 52 09	506 261 573	.001254705
748	55 95 04	418 508 992	.001336898	798	63 68 04	508 169 592	.001253133
749	56 10 01	420 189 749	.001335113	799	63 84 01	510 082 399	.001251564
750	56 25 00	421 875 000	.001333333	800	64 00 00	512 000 000	.001250000

SQUARES, CUBES AND RECIPROCALS—CONTINUED.

Nos.	Squares.	Cubes.	Reciprocals.	Nos.	Squares.	Cubes.	Reciprocals.
801	64 16 01	513 922 401	.001248439	851	72 42 01	616 295 051	.001175088
802	64 32 04	515 849 608	.001246883	852	72 59 04	618 470 208	.001173709
803	64 48 09	517 781 627	.001245330	853	72 76 09	620 650 477	.001172333
804	64 64 16	519 718 464	.001243781	854	72 93 16	622 835 864	.001170960
805	64 80 25	521 660 125	.001242236	855	73 10 25	625 026 375	.001169591
806	64 96 36	523 606 616	.001240695	856	73 27 36	627 222 016	.001168224
807	65 12 49	525 557 943	.001239157	857	73 44 49	629 422 793	.001166861
808	65 28 64	527 514 112	.001237624	858	73 61 64	631 628 712	.001165501
809	65 44 81	529 475 129	.001236094	859	73 78 81	633 839 779	.001164144
810	65 61 00	531 441 000	.001234568	860	73 96 00	636 056 000	.001162791
811	65 77 21	533 411 731	.001233046	861	74 13 21	638 277 381	.001161440
812	65 93 44	535 387 328	.001231527	862	74 30 44	640 503 928	.001160093
813	66 09 69	537 367 797	.001230012	863	74 47 69	642 735 647	.001158749
814	66 25 96	539 353 144	.001228501	864	74 64 96	644 972 544	.001157407
815	66 42 25	541 343 375	.001226994	865	74 82 25	647 214 625	.001156069
816	66 58 56	543 338 496	.001225490	866	74 99 56	649 461 896	.001154734
817	66 74 89	545 338 513	.001223990	867	75 16 89	651 714 363	.001153403
818	66 91 24	547 343 432	.001222494	868	75 34 24	653 972 032	.001152074
819	67 07 61	549 353 259	.001221001	869	75 51 61	656 234 909	.001150748
820	67 24 00	551 368 000	.001219512	870	75 69 00	658 503 000	.001149425
821	67 40 41	553 387 661	.001218027	871	75 86 41	660 776 311	.001148106
822	67 56 84	555 412 248	.001216545	872	76 03 84	663 054 848	.001146789
823	67 73 29	557 441 767	.001215067	873	76 21 29	665 338 617	.001145475
824	67 89 76	559 476 224	.001213592	874	76 38 76	667 627 624	.001144165
825	68 06 25	561 515 625	.001212121	875	76 56 25	669 921 875	.001142857
826	68 22 76	563 559 976	.001210654	876	76 73 76	672 221 376	.001141553
827	68 39 29	565 609 283	.001209190	877	76 91 29	674 526 133	.001140251
828	68 55 84	567 663 552	.001207729	878	77 08 84	676 836 152	.001138952
829	68 72 41	569 722 789	.001206273	879	77 26 41	679 151 439	.001137656
830	68 89 00	571 787 000	.001204819	880	77 44 00	681 472 000	.001136364
831	69 05 61	573 856 191	.001203369	881	77 61 61	683 797 841	.001135074
832	69 22 24	575 930 368	.001201923	882	77 79 24	686 128 968	.001133787
833	69 38 89	578 009 537	.001200480	883	77 96 89	688 465 387	.001132503
834	69 55 56	580 093 704	.001199041	884	78 14 56	690 807 104	.001131222
835	69 72 25	582 182 875	.001197605	885	78 32 25	693 154 125	.001129944
836	69 88 96	584 277 056	.001196172	886	78 49 96	695 506 456	.001128668
837	70 05 69	586 376 253	.001194743	887	78 67 69	697 864 103	.001127396
838	70 22 44	588 480 472	.001193317	888	78 85 44	700 227 072	.001126126
839	70 39 21	590 589 719	.001191895	889	79 03 21	702 595 369	.001124859
840	70 56 00	592 704 000	.001190476	890	79 21 00	704 969 000	.001123596
841	70 72 81	594 823 321	.001189061	891	79 38 81	707 347 971	.001122334
842	70 89 64	596 947 688	.001187648	892	79 56 64	709 732 288	.001121076
843	71 06 49	599 077 107	.001186240	893	79 74 49	712 121 957	.001119821
844	71 23 36	601 211 584	.001184834	894	79 92 36	714 516 984	.001118568
845	71 40 25	603 351 125	.001183432	895	80 10 25	716 917 375	.001117318
846	71 57 16	605 495 736	.001182033	896	80 28 16	719 323 136	.001116071
847	71 74 09	607 645 423	.001180638	897	80 46 09	721 734 273	.001114827
848	71 91 04	609 800 192	.001179245	898	80 64 04	724 150 792	.001113586
849	72 08 01	611 960 049	.001177856	899	80 82 01	726 572 699	.001112347
850	72 25 00	614 125 000	.001176471	900	81 00 00	729 000 000	.001111111

SQUARES, CUBES AND RECIPROCALS—CONTINUED.

Nos.	Squares.	Cubes.	Reciprocals.	Nos.	Squares.	Cubes.	Reciprocals.
901	81 18 01	731 432 701	.001109878	951	90 44 01	860 085 351	.001051525
902	81 36 04	733 870 808	.001108647	952	90 63 04	862 801 408	.001050420
903	81 54 09	736 314 327	.001107420	953	90 82 09	865 523 177	.001049318
904	81 72 16	738 763 264	.001106195	954	91 01 16	868 250 664	.001048218
905	81 90 25	741 217 625	.001104972	955	91 20 25	870 983 875	.001047120
906	82 08 36	743 677 416	.001103753	956	91 39 36	873 722 816	.001046025
907	82 26 49	746 142 643	.001102536	957	91 58 49	876 467 493	.001044932
908	82 44 64	748 613 312	.001101322	958	91 77 64	879 217 912	.001043841
909	82 62 81	751 089 429	.001100110	959	91 96 81	881 974 079	.001042753
910	82 81 00	753 571 000	.001098901	960	92 16 00	884 736 000	.001041667
911	82 99 21	756 058 031	.001097695	961	92 35 21	887 503 681	.001040583
912	83 17 44	758 550 528	.001096491	962	92 54 44	890 277 128	.001039501
913	83 35 69	761 048 497	.001095290	963	92 73 69	893 056 347	.001038422
914	83 53 96	763 551 944	.001094092	964	92 92 96	895 841 344	.001037344
915	83 72 25	766 060 875	.001092896	965	93 12 25	898 632 125	.001036269
916	83 90 56	768 575 296	.001091703	966	93 31 56	901 428 696	.001035197
917	84 08 89	771 095 213	.001090513	967	93 50 89	904 231 063	.001034126
918	84 27 24	773 620 632	.001089325	968	93 70 24	907 039 232	.001033058
919	84 45 61	776 151 559	.001088139	969	93 89 61	909 853 209	.001031992
920	84 64 00	778 688 000	.001086957	970	94 09 00	912 673 000	.001030928
921	84 82 41	781 229 961	.001085776	971	94 28 41	915 498 611	.001029866
922	85 00 84	783 777 448	.001084599	972	94 47 84	918 330 048	.001028807
923	85 19 29	786 330 467	.001083423	973	94 67 29	921 167 317	.001027749
924	85 37 76	788 889 024	.001082251	974	94 86 76	924 010 424	.001026694
925	85 56 25	791 453 125	.001081081	975	95 06 25	926 859 375	.001025641
926	85 74 76	794 022 776	.001079914	976	95 25 76	929 714 176	.001024590
927	85 93 29	796 597 983	.001078749	977	95 45 29	932 574 833	.001023541
928	86 11 84	799 178 752	.001077586	978	95 64 84	935 441 352	.001022495
929	86 30 41	801 765 089	.001076426	979	95 84 41	938 313 739	.001021450
930	86 49 00	804 357 000	.001075269	980	96 04 00	941 192 000	.001020408
931	86 67 61	806 954 491	.001074114	981	96 23 61	944 076 141	.001019368
932	86 86 24	809 557 568	.001072961	982	96 43 24	946 966 168	.001018330
933	87 04 89	812 166 237	.001071811	983	96 62 89	949 862 087	.001017294
934	87 23 56	814 780 504	.001070664	984	96 82 56	952 763 904	.001016260
935	87 42 25	817 400 375	.001069519	985	97 02 25	955 671 625	.001015228
936	87 60 96	820 025 856	.001068376	986	97 21 96	958 585 256	.001014199
937	87 79 69	822 656 953	.001067236	987	97 41 69	961 504 803	.001013171
938	87 98 44	825 293 672	.001066098	988	97 61 44	964 430 272	.001012146
939	88 17 21	827 936 019	.001064963	989	97 81 21	967 361 669	.001011122
940	88 36 00	830 584 000	.001063830	990	98 01 00	970 299 000	.001010101
941	88 54 81	833 237 621	.001062699	991	98 20 81	973 242 271	.001009082
942	88 73 64	835 896 888	.001061571	992	98 40 64	976 191 488	.001008065
943	88 92 49	838 561 807	.001060445	993	98 60 49	979 146 657	.001007049
944	89 11 36	841 232 384	.001059322	994	98 80 36	982 107 784	.001006036
945	89 30 25	843 908 625	.001058201	995	99 00 25	985 074 875	.001005025
946	89 49 16	846 590 536	.001057082	996	99 20 16	988 047 936	.001004016
947	89 68 09	849 278 123	.001055966	997	99 40 09	991 026 973	.001003009
948	89 87 04	851 971 392	.001054852	998	99 60 04	994 011 992	.001002004
949	90 06 01	854 670 349	.001053741	999	99 80 01	997 002 999	.001001001
950	90 25 00	857 375 000	.001052632	1000	1 00 00 00	1 000 000 000	.001000000

DECIMALS OF AN INCH FOR EACH $\frac{1}{64}$th.

$\frac{1}{32}$ds.	$\frac{1}{64}$ths.	Decimal.	Fraction	$\frac{1}{32}$ds.	$\frac{1}{64}$ths.	Decimal.	Fraction
	1	.015625			33	.515625	
1	2	.03125		17	34	.53125	
	3	.046875			35	.546875	
2	4	.0625	1-16	18	36	.5625	9-16
	5	.078125			37	.578125	
3	6	.09375		19	38	.59375	
	7	.109375			39	.609375	
4	8	.125	1-8	20	40	.625	5-8
	9	.140625			41	.640625	
5	10	.15625		21	42	.65625	
	11	.171875			43	.671875	
6	12	.1875	3-16	22	44	.6875	11-16
	13	.203125			45	.703125	
7	14	.21875		23	46	.71875	
	15	.234375			47	.734375	
8	16	.25	1-4	24	48	.75	3-4
	17	.265625			49	.765625	
9	18	.28125		25	50	.78125	
	19	.296875			51	.796875	
10	20	.3125	5-16	26	52	.8125	13-16
	21	.328125			53	.828125	
11	22	.34375		27	54	.84375	
	23	.359375			55	.859375	
12	24	.375	3-8	28	56	.875	7-8
	25	.390625			57	.890625	
13	26	.40625		29	58	.90625	
	27	.421875			59	.921875	
14	28	.4375	7-16	30	60	.9375	15-16
	29	.453125			61	.953125	
15	30	.46875		31	62	.96875	
	31	.484375			63	.984375	
16	32	.5	1-2	32	64	1.	1

DECIMALS OF A FOOT FOR EACH $\frac{1}{64}$ OF AN INCH.

Inch.	0″	1″	2″	3″	4″	5″
0	0	.0833	.1667	.2500	.3333	.4167
$\frac{1}{64}$	.0013	.0846	.1680	.2513	.3346	.4180
$\frac{1}{32}$	.0026	.0859	.1693	.2526	.3359	.4193
$\frac{3}{64}$	.0039	.0872	.1706	.2539	.3372	.4206
$\frac{1}{16}$	.0052	.0885	.1719	.2552	.3385	.4219
$\frac{5}{64}$	.0065	.0898	.1732	.2565	.3398	.4232
$\frac{3}{32}$	.0078	.0911	.1745	.2578	.3411	.4245
$\frac{7}{64}$	.0091	.0924	.1758	.2591	.3424	.4258
$\frac{1}{8}$	.0104	.0937	.1771	.2604	.3437	.4271
$\frac{9}{64}$	.0117	.0951	.1784	.2617	.3451	.4284
$\frac{5}{32}$	.0130	.0964	.1797	.2630	.3464	.4297
$\frac{11}{64}$	.0143	.0977	.1810	.2643	.3477	.4310
$\frac{3}{16}$	.0156	.0990	.1823	.2656	.3490	.4323
$\frac{13}{64}$	.0169	.1003	.1836	.2669	.3503	.4336
$\frac{7}{32}$	.0182	.1016	.1849	.2682	.3516	.4349
$\frac{15}{64}$	.0195	.1029	.1862	.2695	.3529	.4362
$\frac{1}{4}$	.0208	.1042	.1875	.2708	.3542	.4375
$\frac{17}{64}$	.0221	.1055	.1888	.2721	.3555	.4388
$\frac{9}{32}$	.0234	.1068	.1901	.2734	.3568	.4401
$\frac{19}{64}$	.0247	.1081	.1914	.2747	.3581	.4414
$\frac{5}{16}$	.0260	.1094	.1927	.2760	.3594	.4427
$\frac{21}{64}$	.0273	.1107	.1940	.2773	.3607	.4440
$\frac{11}{32}$	.0286	.1120	.1953	.2786	.3620	.4453
$\frac{23}{64}$	.0299	.1133	.1966	.2799	.3633	.4466
$\frac{3}{8}$	.0312	.1146	.1979	.2812	.3646	.4479
$\frac{25}{64}$	.0326	.1159	.1992	.2826	.3659	.4492
$\frac{13}{32}$	.0339	.1172	.2005	.2839	.3672	.4505
$\frac{27}{64}$	.0352	.1185	.2018	.2852	.3685	.4518
$\frac{7}{16}$	.0365	.1198	.2031	.2865	.3698	.4531
$\frac{29}{64}$	.0378	.1211	.2044	.2878	.3711	.4544
$\frac{15}{32}$	.0391	.1224	.2057	.2891	.3724	.4557
$\frac{31}{64}$	.0404	.1237	.2070	.2904	.3737	.4570
$\frac{1}{2}$	.0417	.1250	.2083	.2917	.3750	.4583

DECIMALS OF A FOOT FOR EACH $\frac{1}{64}$ OF AN INCH.

Inch.	6″	7″	8″	9″	10″	11″
0	.5000	.5833	.6667	.7500	.8333	.9167
$\frac{1}{64}$	.5013	.5846	.6680	.7513	.8346	.9180
$\frac{1}{32}$	.5026	.5859	.6693	.7526	.8359	.9193
$\frac{3}{64}$	.5039	.5872	.6706	.7539	.8372	.9206
$\frac{1}{16}$	.5052	.5885	.6719	.7552	.8385	.9219
$\frac{5}{64}$	.5065	.5898	.6732	.7565	.8398	.9232
$\frac{3}{32}$	.5078	.5911	.6745	.7578	.8411	.9245
$\frac{7}{64}$	.5091	.5924	.6758	.7591	.8424	.9258
$\frac{1}{8}$	.5104	.5937	.6771	.7604	.8437	.9271
$\frac{9}{64}$	.5117	.5951	.6784	.7617	.8451	.9284
$\frac{5}{32}$	.5130	.5964	.6797	.7630	.8464	.9297
$\frac{11}{64}$	.5143	.5977	.6810	.7643	.8477	.9310
$\frac{3}{16}$	.5156	.5990	.6823	.7656	.8490	.9323
$\frac{13}{64}$	.5169	.6003	.6836	.7669	.8503	.9336
$\frac{7}{32}$	5182	.6016	.6849	.7682	.8516	.9349
$\frac{15}{64}$	.5195	.6029	.6862	.7695	.8529	.9362
$\frac{1}{4}$	.5208	.6042	.6875	.7708	.8542	.9375
$\frac{17}{64}$	.5221	.6055	.6888	.7721	.8555	.9388
$\frac{9}{32}$	.5234	.6068	.6901	.7734	.8568	.9401
$\frac{19}{64}$	.5247	.6081	.6914	.7747	.8581	.9414
$\frac{5}{16}$	.5260	.6094	.6927	.7760	.8594	.9427
$\frac{21}{64}$	.5273	.6107	.6940	.7773	.8607	.9440
$\frac{11}{32}$	.5286	.6120	.6953	.7786	.8620	.9453
$\frac{23}{64}$	.5299	.6133	.6966	.7799	.8633	.9466
$\frac{3}{8}$	.5312	.6146	.6979	.7812	.8646	.9479
$\frac{25}{64}$	.5326	.6159	.6992	.7826	.8659	.9492
$\frac{13}{32}$	.5339	.6172	.7005	.7839	.8672	.9505
$\frac{27}{64}$	.5352	.6185	.7018	.7852	.8685	.9518
$\frac{7}{16}$	.5365	.6198	.7031	.7865	.8698	.9531
$\frac{29}{64}$	.5378	.6211	.7044	.7878	.8711	.9544
$\frac{15}{32}$	.5391	.6224	.7057	.7891	.8724	.9557
$\frac{31}{64}$	.5404	.6237	.7070	.7904	.8737	.9570
$\frac{1}{2}$	.5417	.6250	.7083	.7917	.8750	.9583

DECIMALS OF A FOOT FOR EACH $\frac{1}{64}$ OF AN INCH.

Inch.	0″	1″	2″	3″	4″	5″
$\frac{33}{64}$	.0430	.1263	.2096	.2930	.3763	.4596
$\frac{17}{32}$	.0443	.1276	.2109	.2943	.3776	.4609
$\frac{35}{64}$	.0456	.1289	.2122	.2956	.3789	.4622
$\frac{9}{16}$	.0469	.1302	.2135	.2969	.3802	.4635
$\frac{37}{64}$	.0482	.1315	.2148	.2982	.3815	.4648
$\frac{19}{32}$	.0495	.1328	.2161	.2995	.3828	.4661
$\frac{39}{64}$	.0508	.1341	.2174	.3008	.3841	.4674
$\frac{5}{8}$	.0521	.1354	.2188	.3021	.3854	.4688
$\frac{41}{64}$	.0534	.1367	.2201	.3034	.3867	.4701
$\frac{21}{32}$	.0547	.1380	.2214	.3047	.3880	.4714
$\frac{43}{64}$	.0560	.1393	.2227	.3060	.3893	.4727
$\frac{11}{16}$	.0573	.1406	.2240	.3073	.3903	.4740
$\frac{45}{64}$	.0586	.1419	.2253	.3086	.3919	.4753
$\frac{23}{32}$	.0599	.1432	.2266	.3099	.3932	.4766
$\frac{47}{64}$	.0612	.1445	.2279	.3112	.3945	.4779
$\frac{3}{4}$	.0625	.1458	.2292	.3125	.3958	.4792
$\frac{49}{64}$	.0638	.1471	.2305	.3138	.3971	.4805
$\frac{25}{32}$	.0651	.1484	.2318	.3151	.3984	.4818
$\frac{51}{64}$	.0664	.1497	.2331	.3164	.3997	.4831
$\frac{13}{16}$	0677	.1510	.2344	.3177	.4010	4844
$\frac{53}{64}$	.0690	.1523	.2357	.3190	.4023	.4857
$\frac{27}{32}$	.0703	.1536	.2370	.3203	.4036	.4870
$\frac{55}{64}$	.0716	.1549	.2383	.3216	.4049	.4883
$\frac{7}{8}$	.0729	.1562	.2396	.3229	.4062	.4896
$\frac{57}{64}$	.0742	.1576	.2409	.3242	.4076	.4909
$\frac{29}{32}$	.0755	.1589	.2422	.3255	.4089	.4922
$\frac{59}{64}$	.0768	.1602	.2435	.3268	.4102	.4935
$\frac{15}{16}$	.0781	.1615	.2448	.3281	.4115	.4948
$\frac{61}{64}$	.0794	.1628	.2461	3294	.4128	.4961
$\frac{31}{32}$	.0807	.1641	.2474	.3307	.4141	.4974
$\frac{63}{64}$	.0820	.1654	.2487	.3320	.4154	.4987
1						

DECIMALS OF A FOOT FOR EACH $\frac{1}{64}$ OF AN INCH.

Inch.	6″	7″	8″	9″	10″	11″
$\frac{33}{64}$	.5430	.6263	.7096	.7930	.8763	.9596
$\frac{17}{32}$	.5443	.6276	.7109	.7943	.8776	.9609
$\frac{35}{64}$	.5456	.6289	.7122	.7956	.8789	.9622
$\frac{9}{16}$	.5469	.6302	.7135	.7969	.8802	.9635
$\frac{37}{64}$	.5482	.6315	.7148	.7982	.8815	.9648
$\frac{19}{32}$	.5495	.6328	.7161	.7995	.8828	.9661
$\frac{39}{64}$	.5508	6341	.7174	.8008	.8841	.9674
$\frac{5}{8}$	.5521	.6354	.7188	.8021	.8854	.9688
$\frac{41}{64}$	.5534	.6367	.7201	.8034	.8867	.9701
$\frac{21}{32}$	.5547	.6380	.7214	.8047	.8880	.9714
$\frac{43}{64}$	.5560	.6393	.7227	.8060	.8893	.9727
$\frac{11}{16}$	.5573	.6406	.7240	.8073	.8906	.9740
$\frac{45}{64}$	.5586	.6419	.7253	.8086	.8919	.9753
$\frac{23}{32}$	.5599	.6432	.7266	.8099	.8932	.9766
$\frac{47}{64}$	.5612	.6445	7279	8112	.8945	.9779
$\frac{3}{4}$	.5625	.6458	.7292	.8125	.8958	.9792
$\frac{49}{64}$	.5638	.6471	.7305	.8138	.8971	.9805
$\frac{25}{32}$	.5651	.6484	.7318	.8151	.8984	.9818
$\frac{51}{64}$	.5664	.6497	7331	.8164	.8997	.9831
$\frac{13}{16}$	.5677	.6510	.7344	.8177	.9010	.9844
$\frac{53}{64}$	.5690	.6523	.7357	.8190	.9023	.9857
$\frac{27}{32}$	.5703	.6536	.7370	.8203	.9036	.9870
$\frac{55}{64}$	.5716	.6549	.7383	.8216	.9049	.9883
$\frac{7}{8}$	.5729	.6562	.7396	.8229	.9062	.9896
$\frac{57}{64}$	.5742	.6576	.7409	.8242	.9076	.9909
$\frac{29}{32}$	.5755	.6589	.7422	.8255	.9089	.9922
$\frac{59}{64}$	.5768	.6602	.7435	.8268	.9102	.9935
$\frac{15}{16}$	.5781	.6615	.7448	.8281	.9115	.9948
$\frac{61}{64}$	.5794	.6628	.7461	.8294	.9128	.9961
$\frac{31}{32}$	.5807	.6641	.7474	.8307	.9141	.9974
$\frac{63}{64}$	.5820	.6654	.7487	.8320	.9154	.9987
1						1.0000

MENSURATION.

LENGTH.

Circumference of circle = diameter × 3.1416.
Diameter of circle = circumference × 0.3183.
Side of square of equal periphery as circle = diameter × 0.7854.
Diameter of circle of equal periphery as square = side × 1.2732.
Side of an inscribed square = diameter of circle × 0.7071.
Length of arc = No. of degrees × diameter × 0.008727.
Circumference of circle whose diameter is 1 =

$$\pi = 3.14159265.$$

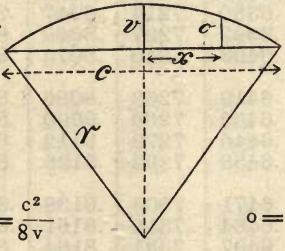
$\log.\pi = 0.4971499.$

$\sqrt{\pi} = 1.772454.$

$\pi^2 = 9.869604.$

$$r = \frac{v^2 + \frac{c^2}{4}}{2v}$$

or, very nearly, $= \frac{c^2}{8v}$



$\frac{1}{\pi} = 0.318310.$

$\frac{1}{\pi^2} = 0.101321.$

$\sqrt{\frac{1}{\pi}} = 0.564190.$

$o = \sqrt{r^2 - x^2} - (r - v)$

$$v = r - \sqrt{r^2 - \frac{c^2}{4}} \text{ or, very nearly, } = \frac{c^2}{8r}$$

AREA.

Triangle = base × half perpendicular hight.
Parallelogram = base × perpendicular hight.
Trapezoid = half the sum of the parallel sides × perpendicular hight.
Trapezium, found by dividing into two triangles.
Circle = diameter squared × 0.7854; or,
= circumference squared × 0.07958.
Sector of circle = length of arc × half radius.

MENSURATION—Continued.

Segment of circle = area of sector less triangle; also, for flat segments very nearly $= \frac{4\,v}{3}\sqrt{0.388\ v^2 + \frac{c^2}{4}}$

Side of square of equal area as circle = diameter × 0.8862; also, = circumference × 0.2821.

Diameter of circle of equal area as square = side × 1.1284.

Parabola = base × ⅔ hight.

Ellipse = long diameter × short diameter × 0.7854.

Regular polygon = sum of sides × half perpendicular distance from center to sides.

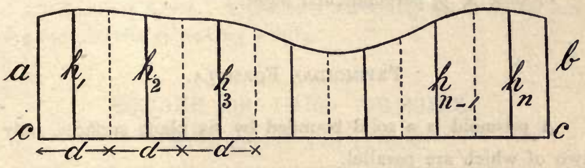
Surface of cylinder = circumference × hight × area of both ends.

Surface of sphere = diameter squared × 3.1416;
also, = circumference × diameter.

Surface of a right pyramid or cone = periphery or circumference of base × half slant hight.

Surface of a frustrum of a regular right pyramid or cone = sum of peripheries or circumferences of the two ends × half slant hight + area of both ends.

The following formulæ are used to obtain the areas of irregular plane surfaces which are bounded by a base line, "*cc*," and two ordinates, "*a*" and "*b*," as per figure.



The formulæ are given in the order of their accuracy, beginning with the most accurate.

The surface is divided into any number (n) of parallel strips having the same widths, d, and whose middle ordinates are represented by $h_1\ h_2\ h_3 \ldots\ldots\ldots\ldots\ h_{n-1}$ and h_n

MENSURATION—Continued.

I. $\text{Area} = d \times \Sigma h + \frac{d}{72}(8a + h_2 - 9h_1) + \frac{d}{72}(8b + h_{n-1} - 9h_n)$

(Francke's rule.)

II. $\text{Area} = d \times \Sigma h + \frac{d}{12}(a - h_1) + \frac{d}{12}(b - h_n)$

(Poncelet's rule.)

III. $\text{Area} = d \times \Sigma h.$

These formulæ are more convenient for use than Simpson's rule, and I and II give generally and III sometimes more accurate results.

Σ stands for *sum of.*

SOLID CONTENTS.

Prism, right or oblique, = area of base × perpendicular hight.
Cylinder, right or oblique, = area of section at right angles to sides × length of side.
Sphere = diameter cubed × 0.5236.
also, = surface × 1/6 diameter.
Pyramid or cone, right or oblique, regular or irregular, = area of base × 1/3 perpendicular hight.

Prismoidal Formula.

A prismoid is a solid bounded by six plane surfaces, only two of which are parallel.

To find the contents of a prismoid, add together the areas of the two parallel surfaces and four times the area of a section taken midway between and parallel to them, and multiply the sum by 1/6th of the perpendicular distance between the parallel surfaces.

WEIGHTS AND MEASURES.

AVOIRDUPOIS OR ORDINARY COMMERCIAL WEIGHT.

UNITED STATES AND BRITISH.

Ton.	Cwts.	Pounds.	Ounces.
1.	20.	2240.	35840.
0.050	1.	112.	1792.
	0.0089	1.	16.
		0.0625	1.

1 pound = 27.7 cubic inches of distilled water at its maximum density, (39° Fahrenheit.)

LONG MEASURE.

UNITED STATES AND BRITISH.

Miles.	Rods.	Yards.	Feet.	Inches.
1.	320.	1760.	5280.	63360.
0.003125	1.	5.5	16.5	198.
0.000568	0.1818	1.	3.	36.
0.0001894	0.0606	0.3333	1.	12.
0.0000158	0.005051	0.02778	0.08333	1.

The British measures are shorter than those of the U. S. by about 1 part in 17230 or 3.677 inches in a mile.

A fathom = 6 feet. A Gunter's surveying chain = 66 feet or 4 rods, 80 chains making a mile.

SQUARE OR LAND MEASURE.

UNITED STATES AND BRITISH.

Sq. Miles.	Acres.	Sq. Rods.	Sq. Yards.	Sq. Feet.	Sq. Inches.
1.	640.	102400.	3097600.	27878400.	
	1.	160.	4840.	43560.	6272640.
		1.	30.25	272.25	39204.
		0.0331	1.	9.0	1296.
			0.111	1.	144.
				0.00694	1.

WEIGHTS AND MEASURES—Continued.

CUBIC OR SOLID MEASURE.

UNITED STATES AND BRITISH.

1728 cubic inches = 1 cubic foot.

27 cubic feet = 1 cubic yard.

A cord of wood = $4' \times 4' \times 8'$ = 128 cubic feet.

A perch of masonry = $16.5' \times 1.5' \times 1'$ = 24.75 cubic feet, but is generally assumed at 25 cubic feet.

DRY MEASURE.

UNITED STATES ONLY.

Struck Bush	Pecks.	Quarts.	Pints.	Gallons.	Cubic Inch.
1	4	32.	64	8.	2150.
	1	8.	16	2.	537.6
		1.	2	0.25	67.2
		0.5	1	0.125	33.6
		4.	8	1.	268.8

A gallon of liquid measure = 231 cubic inches.

A heaped bushel = $1\frac{1}{4}$ struck bushels. The cone in a heaped bushel must be not less than 6 inches high.

A barrel of U. S. hydraulic cement = 300 to 310 lbs., usually, and of genuine Portland cement = 425 lbs.

To reduce U. S. dry measures to British imperial of the same name, divide by 1.032.

NAUTICAL MEASURE.

A nautical or sea mile is the length of a minute of longitude of the earth at the equator at the level of the sea. It is assumed = 6086.07 feet = 1.152664 statute or land miles by the United States Coast Survey.

3 nautical miles = 1 league.

COMPARATIVE TABLE OF

UNITED STATES AND FRENCH MEASURES.

MEASURES.	No.
One grain = gramme, - - -	0.0648
One pound avoirdupois = kilogramme, - -	0.4536
One ton of 2240 lbs. = tonnes, - -	1.0160
One ton of 2000 lbs. = tonne, - - -	0.9071
One inch = millimetres, - - -	25.400
One foot = metre, - - - -	0.3048
One mile = kilometres, - - -	1.6094
One square inch = square millimetres, - -	645.2
One square foot = square metre, - -	0.09291
One acre = are (100 square metres), - -	40.47
One square mile = square kilometres, -	2.590
One cubic inch = cubic centimetres, - -	16.39
One cubic foot = cubic metre, - -	0.02832
One cubic yard = cubic metre, - - -	0.7646
One quart dry measure = litres, - -	1.101
One quart liquid or wine measure = litre, -	0.9465
One foot pound = kilogrammetre, - -	0.1383
One pound per foot = kilogrammes per metre, -	1.488
One thousand pounds per square inch = kilogramme per square millimetre, - - -	0.703
One pound per square foot = kilogrammes per square metre, - - - -	4.882
One pound per cubic foot = kilogrammes per cubic metre, - - - -	16.02
One degree Fahrenheit = degree centigrade,	0.5556

COMPARATIVE TABLE OF
FRENCH AND UNITED STATES MEASURES.

MEASURES.	No.
One gramme = grains, - - -	15.433
One kilogramme = pounds avoirdupois, - -	2.2047
One tonne = tons of 2240 lbs. - -	0.9843
One tonne = tons of 2000 lbs. - - -	1.1024
One millimetre = inch, - - -	0.0394
One metre = feet, - - - -	3.2807
One kilometre = mile, - - -	0.6213
One square millimetre = square inch, - -	0.00155
One square metre = square feet, - -	10.763
One are (100 square metres) = acres, - -	0.02471
One square kilometre = square mile, -	0.3861
One cubic centimetre = cubic inch, -	0.0610
One cubic metre or stere = cubic feet, -	35.3105
One cubic metre = cubic yards, - - -	1.3078
One litre (one cubic decimetre) = cubic inches,	61.017
One litre = quarts, dry measure, - - -	0.908
One litre = quarts, liquid or wine measure, -	1.0566
One kilogrammetre = foot pounds, - -	7.2331
One kilogramme per metre = pounds per foot,	0.6720
One kilogramme per square millimetre = pounds per square inch, - - - -	1422
One kilogramme per square metre = pounds per square foot, - - - -	0.2048
One kilogramme per cubic metre = pounds per cubic foot, - - - -	0.0624
One degree centigrade = degrees Fahrenheit, -	1.8

THE CARNEGIE STEEL COMPANY, LIMITED,

OWNS AND OPERATES THE FOLLOWING WORKS:—

Edgar Thomson Furnaces, - -	Bessemer,
Lucy Furnaces, - - - -	Pittsburg,
Edgar Thomson Steel Works, -	Bessemer,
Duquesne Steel Works, - - -	Duquesne,
Homestead Steel Works, - -	Munhall,
Keystone Bridge Works, - - -	Pittsburg,
Upper Union Mills, - - - -	Pittsburg,
Lower Union Mills, - - - -	Pittsburg,
Beaver Falls Mills, - - - -	Beaver Falls,
Larimer Coke Works, - - -	Larimer,
Youghiogheny Coke Works, - -	Douglass,
Scotia Ore Mines, - - - - -	Benore.

—AT WHICH ARE PRODUCED:—

Armor Plate,

Billets (1½″ up), Blooms, Slabs, Coke.

Ferro Manganese, Spiegel-eisen, Pig Iron.

Forgings, such as Axles, Arch Bars, Links, Pins and other Car Forgings, Connecting Rods, Crank Shafts, Locomotive Frames, Eye Bars.

Plates for Boilers, Bridges, Ships and Tanks.

Rails, (16 to 85 lbs. per yd.).

Rolled Structural Shapes, such as Angles, Rounds, Flats, Squares, Ovals, I-Beams, Channels, Bulb Angles, Deck Beams, Tees, Zees, etc.

Structural Work, such as Bridges, Buildings, Elevated Railroads, Girders, Columns, etc.

Wire, Wire Nails and Wire Rods.

—ADDRESS:—

General Offices;

42-48, Fifth Avenue, Pittsburg,

or Sales Offices;

10, Marietta St., Atlanta;

125, Milk St., Boston;

451, Main St., Buffalo;

205, La Salle St., Chicago;

126, W. Fourth St., Cincinnati;

103, Superior St., Cleveland;

Peoples Bank Building, Denver;

122, Griswold St., Detroit;

Guaranty Building, Minneapolis;

44-46, Wall St., New York;

203, S. Fourth St., Philadelphia;

604, Pine St., St. Louis;

258, Market St., San Francisco.

INDEX.

artificial heating for store and offices.
Vault 9'3" x 13'6"

Largest size 26 oz. glass = 44 x 80 or 50 x 60

1893

ID